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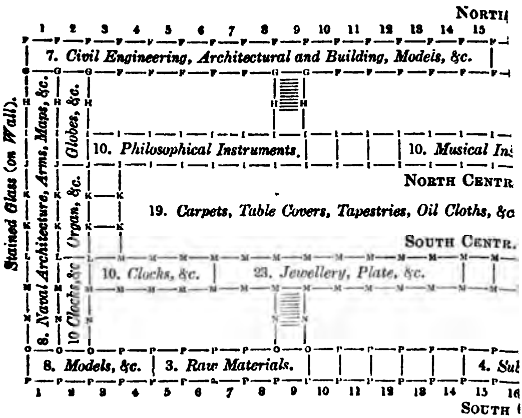
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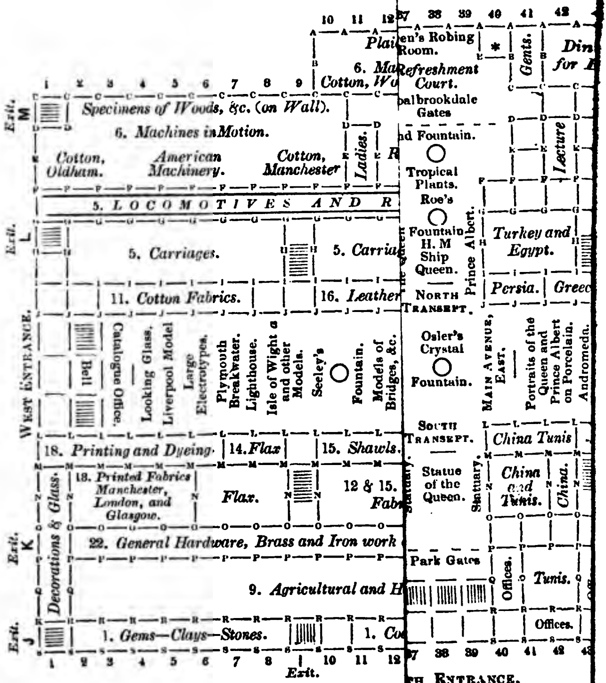

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HUNT'S HAND-BOOK

TO THE

Official Catalogues:

AN

EXPLANATORY GUIDE TO THE NATURAL PRODUCTIONS
AND MANUFACTURES OF THE GREAT EXHIBITION
OF THE INDUSTRY OF ALL NATIONS, 1851.

EDITED BY
ROBERT HUNT,
KEEPER OF MINING RECORDS,
AUTHOR OF "RESEARCHES ON LIGHT," "THE POETRY OF SCIENCE,"
"SYNOPSIS," &c. &c.

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AT HYDE PARK.

CONTENTS.

HUNT'S HANDBOOK

TO

THE OFFICIAL CATALOGUES.

THE TRANSEPT.

As the visiter approaches the Transept entrance to the Great Exhibition Building attention is naturally attracted towards the novel character of two long gilded index-hands moving across a semicircle, divided by the radii of the framing, on which are marked the 12 hours. Being accustomed to the circular clock-face, this disposition of the divisions to indicate the march of time at first strikes us as strange; but a very brief consideration will show that the hours and minutes are read off as easily from this arrangement, which was adopted to avoid any interference with the design of the Building, as from an ordinary dial. However, those large index hands are most appropriately placed, forming, as they do, an exemplification of one of those applications of abstract science which distinguishingly marks the present age. They are regulated in their movements by *electrical force*. The attraction and repulsion of induced magnetic power, nicely regulated by mechanical ingenuity, have superseded the old clock-weights, and the means are easy by which we may regulate the clocks of a city, making their movements isochronous with this horologe in front of the Industrial Palace. This example, and the allied application of electrical power, appear as the culminating points of man's triumph over the great physical forces by which the conditions of the universe are determined: the electric

clock, which must be described with the Philosophical Instruments, therefore very properly marks the entrance to this Great Exhibition of the Works of Industry of all Nations.

Passing into the Building we tread upon some fine examples of *slates from Llangollen;* and entering through the ornamental iron gates, which are good illustrations of the present state of cast-iron manufacture in this country, the grand features of the Transept open themselves.

The statuary disposed on either side, lending that beauty to the scene which art ever sheds around it, well marks the centre of the Building. The mere application of native productions to the useful purposes of life should not be the end of our industrial labours—thought should tend ever towards the realization of the beautiful; and even the form of the most ordinary manufacture should be designed upon a system by which symmetry should be secured. Thus the study of the most elevated of the arts, sculpture, becomes immediately connected with the labours of the forge, of the smith, or the productions of the wheel of the potter.

The business of the Handbook is not, however, with these developments of the ideal: designed to be purely instructive, objects of taste are left to speak their own language—to be their own interpreters.

The Crystal Fountain (20) of the Messrs. F. and C. Osler is manufactured of the purest flint-glass, which is technically called "crystal," from its pellucid and brilliant character. It possesses a very high refracting power, imparted to it by the oxide of lead which enters into its composition; hence the fine play of prismatic colours which are observable at some angles. There are points about the manufacture of this fountain which are curious. The framing of the whole is metallic; the weight of the glass nearly four tons, requiring supports of iron—these are, however, silvered on their outer surface. The glass, previously to its being placed in its position, has been most

carefully cut, and to nearly the whole of it the prismatic form has been given: the object of this being to secure a total reflection of all the light which falls upon the surface. By this means the base of every prism becoming a reflecting surface, great brilliancy is obtained, and the metal supports are entirely hidden. The fountain is 24 feet high; and the leaf-like portions of it are stated to be some of the largest masses of flint-glass ever manufactured in one piece. The principal dish is upwards of 8 feet diameter and weighed before cutting nearly a ton. The shells weighed 50 lbs. each previously to their being cut.

The Model of H.M. Ship Queen should be inspected, as it exhibits all the peculiarities of one of the finest examples of our Naval Architecture, she being one of our first-rate men-of-war, carrying 116 guns.

A little north of the glass fountain is another, associated with an example of the *Hydraulic Ram* (462:). In this machine, the momentum of a stream of water through a long pipe is employed for raising a small quantity to a considerable height. The passage of the pipe being stopped by a valve, which is raised by the stream as soon as its motion becomes sufficiently rapid, the whole column of fluid must necessarily concentrate its action almost instantaneously on the valve, and in this manner it loses its characteristic property of hydraulic pressure, and acts as if it were a single solid; so that, supposing the pipe to be perfectly elastic and inextensible, the impulse must overcome any pressure, however great, that might be opposed to it, and if the valve open into a pipe leading to an air-vessel, a certain quantity of the water will be forced in, so as to condense the air more or less rapidly, to a degree that may be required for raising a portion of the water contained in it to any given height. Mr. Whitehurst appears to have been the first that employed this method. It was afterwards much improved by Mr. Boulton; and the same machine has lately attracted much attention in France, under the denomination of the Hydraulic ram of Montgolfier.

The Cast-iron Fountain and the *Park Gates*, on the north side of the Transept, should be inspected as examples of improvements in metal castings. Each of the four gates was cast in one piece. In noticing the other works of this, the Coalbrook-dale Company, the peculiar conditions required to produce a fine iron casting will be described. These, and the figures of the "Eagle-slayer" and "Andromeda," are also illustrations of bronzing iron. This is effected in various ways: in some it is nothing more than a paint; in others bronzing is produced by a chemical application to the surface of the metal. The chloride of platinum produces a very fine colour upon the surface of iron; but a compound solution of the sulphate of copper and muriate of iron is more commonly employed, the platinum salt being very expensive.

Ward's Cases of Exotic Ferns, &c., are in this section. The general impression is, that these are air-tight, and hence that the delicate ferns of the tropics are preserved healthfully in the dense atmosphere of cities by the entire exclusion of the impure air. This is a misconception; none of Ward's cases are air-tight. The object is to prevent rapid evaporation from the plant, which requires a humid atmosphere for its existence, to protect the leaves from the obstructions occasioned by the lodging of particles of solid carbon on them, and to allow the air within to change slowly by the operation of the vital forces of the plants themselves. By securing the plants in this manner from any sudden transitions of temperature, these cases are used with much success for transporting tropical plants to colder climates.

For an account of the terra-cotta manufacture, the encaustic and other tiles, examples of which are found on the north side of the Transept, refer to the description given under these headings in Class 25.

Returning to the Glass Fountain, our progress should be westward, that division of the Building being devoted to the United Kingdom and our Colonies. Numerous beau-

tiful examples of art and manufacture occur along the centre of the Main Avenue. Many of these will be described in connection with the classes to which they belong; but there are a few which may be more appropriately dealt with as we pass onward through the centre of the Nave.

West Main Avenue.

In *Keith's Silk Trophy* (1), to be noticed in connection with British silk manufacture, are several fine illustrations of *British Plate-glass* (408). In the *Console Table and Glass* (386) occurs another, and at the western end is fixed the largest plate ever made; it therefore appears important that some notice of their manufacture should be given in this place.

The composition of plate-glass varies considerably, some manufacturers introducing materials which are not to be found in the glass obtained from other works. The general composition is stated to be the following:—

Fine white sand	300 pounds.
Soda	200 ,,
Lime	30 ,,
Oxide of manganese . . .	32 ounces.
Oxide of cobalt	3 ,,
Fragments of glass . . .	300 pounds.

The well-known property of borax, as a powerful flux, has occasioned the suggestion that by its means glass made with potash might be caused to flow in fusion as freely as that wherein soda is employed.

Great care is required in mixing the materials; much more, indeed, than is necessary with other kinds of glass. The sand, lime, soda, and manganese, being properly intermingled, are sometimes *fritted* in small furnaces, wherein the temperature is gradually raised to a full red, or even to a white heat, at which point it is maintained, and the materials are carefully stirred until vapour is no longer given off, and no further change is undergone by the ma-

terials. This process of fritting lasts about six hours, and when it is nearly completed, the remaining part of the ingredients, consisting of the cobalt and broken glass, is added. The latter, having already been perfectly vitrified, does not, consequently, require any lengthened exposure to the fire. Fritting is now, in many manufactories, omitted, the material being placed at once in the large pots, small quantities at a time.

From the time of filling the pots nearly forty hours' exposure to strong heat is necessary before the materials are properly vitrified and in a fit state for casting. When the melted glass in the cuvette is found to be in the exact state that experience has pointed out as being most favourable for its flowing readily and equably, this vessel is withdrawn from the furnace by means of a crane, and is placed upon a low carriage, in order to its removal to the casting table, which, as it is previously placed contiguous to the annealing oven that is to be filled, may therefore be at a considerable distance from the melting furnace. Measures are then taken for cleaning the exterior of the crucible, and for carefully removing with a broad copper sabre any scum that may have formed upon the surface of the glass, as the mixture of any of these foreign matters would infallibly spoil the beauty of the plate. These done, the cuvette is wound up to a sufficient height by a crane, and then, by means of another simple piece of mechanism, is swung over the upper end of the casting table, and being thrown into an inclined position, a torrent of melted glass is suddenly poured out on the surface of the table, which must previously have been heated and wiped perfectly clean.

The glass is prevented from running off the sides of the table by ribs of metal, one of which is placed along the whole length of each side, their depth being the exact measure which it is desired to give to the thickness of the glass. A similar rib, attached to a cross piece, is temporarily held during the casting at the lower end of the table. When the whole contents of the crucible have been

delivered, a large hollow copper cylinder, which has been made perfectly true and smooth in a turning lathe, and which extends entirely across the table, resting on the side ribs, is set in motion, and the glass, during its progress, is spread out into a sheet of uniform breadth and thickness. Its length depends upon the quantity of melted glass contained in the cuvette: should this be more than is needed for the formation of a plate having the full dimensions of the table, the metal rib is removed from its lower part, and the surplus glass is received in a vessel of water placed under the extreme end for that purpose. The plates have then to undergo all the operations of squaring, grinding, polishing, and silvering, in order to fit them for sale.

For the purpose of securing good colour, the oxide of manganese is introduced. The object of this is to peroxidise all extraneous matters; if, however, this is used too largely, it imparts a pink colour to the glass, which goes on increasing under the influence of light. In some instances lead is employed, and if this is in excess, the result is a yellow colour, which is no less objectionable.

The operation of "silvering" plate-glass is one requiring considerable skill and attention. The process, in all its principal points, may be briefly stated as follows:—A sheet of tinfoil being spread out upon an iron or stone table, around which a ledge runs, is covered with mercury (quicksilver). This fluid metal combines with the tin, forming an amalgam, one portion of which remains fluid, whilst the other is solid. The surface being very carefully cleaned, until a most perfect reflecting sheet is obtained, the glass also, cleaned most perfectly, is placed upon it, pressed down by heavy weights, and kept in this position for some time. The fluid amalgam is forced out by the pressure applied, and the solid portion, adhering to the glass, furnishes the reflecting surface.

Up to the period of the removal of the restrictive duties and Excise supervision, we are enabled to state with

accuracy the quantity of plate-glass retained for home consumption—

In 1842 it was	18,396 cwt.	
1843 ,,	17,047 ,,	
1844 ,,	24,405 ,,	

We then imported about 1,000 cwt., or 3,000 feet, annually, principally from France; but the quantity at present used is considerably above these, and the English plate-glass being now even preferred to the French, we export it in large quantities.

Canadian Trophy.—The logs and planks of Canadian timber, of which this fine pile is built, are well worthy of attention. One of the pieces is a polished slab of black walnut, taken from a tree which measured 37 feet in circumference close to the ground, and 28 feet at three feet above the ground. It rose to the height of 61 feet without branching, and yielded 23 logs and 10,000 feet of timber. This kind of walnut is the *Juglans nigra:* its fruit is much inferior to the European walnut; its wood is of a purplish-brown colour, becoming black with age, and is valuable for furniture-making. Along with it is the wood of the curled and birds-eye maple; one of the pieces of the latter in the form of a fine veneer. Both these woods are the produce of the sugar-maple (*Acer saccharinum*), of which the most beautifully-marked pieces are taken from sections made at the crutches or junctions of branches with the trunk. Thus the same tree may furnish birds-eye maple, curled-wood, and wood of no remarkable ornamental quality. The butternut wood is from the *Juglans cinerea*, a species of walnut of less size, and producing a lighter-coloured wood than the black walnut. The specimens of birch and ash are from trees nearly allied to, but not specifically identical with, the birches and ashes of the old world. The trophy is crowned with a canoe from Nova Scotia. These canoes are made of the outer bark of the paper birch (*Betula papyracea*), a large tree whose range is through the wooded districts of the northern parts of North America. They

are constructed by the Indians with surprising rapidity. The bark is sewn together with thongs from the hide of the moose-deer.

At the east end of the pile are two cross sections of a gigantic blue gum-tree (*Eucalyptus globulosa*) from Van Diemen's Land, the diameter of the largest, cut about four feet from the ground, is 3 feet; that of the smallest, cut below the first limb, 135 feet high, is 1 foot 6 inches.

In front of it is a portion of the trunk of an enormous petrified tree, also from Van Diemen's Land. It is completely converted into silex, yet so perfectly are the original tissues replaced by the mineral that, under the microscope, they display the minutest organic structure. These trunks are found embedded vertically in vesicular lava, and were overwhelmed by igneous matter during an ancient volcanic eruption. Dr. Joseph Hooker, who visited them *in situ*, has shown them to be plants of the pine tribe, and to belong to the genus *Araricaria*, but in all probability to be species now extinct. Interesting accounts of the places where they are found are contained in the "Physical Description of Australia," by Count Strzelecki, and in Sir James Ross's "Voyage to the Southern Seas."

Lower Jawbone of Sperm Whale.—At the west end of the pile is a fine specimen of the lower jaw of a sperm whale (*Catodon macrocephalus*?), from the seas around Van Diemen's Land. The upper jaw of this animal is toothless, and the conical teeth of the lower jaw fit into cavities in the edge of the upper one. The teeth are ivory. This whale, so valuable for the sperm oil and spermaceti which it yields, grows to 60 and 70 feet in length.

Restoration of the Monument of Philippa of Hainault, in Westminster Abbey (60).—As an example of carving in English alabaster this is deserving of attention, as being an unusually fine mass. It was procured in Derbyshire, and has been very successfully chiselled by the exhibitor. Alabaster is a sulphate of lime; the finest quality is found in the neighbourhood of Volterra, in Tuscany, at which

place and at Florence it is cut into a variety of works of great beauty and taste. In England alabaster is found in Derbyshire and Staffordshire ; and in these countries it is worked into small ornaments and toys.

The Purbeck Marble Tablet (61), *Caen Stone Cross* (79), *and the Columns of Madrepore Marble* (158), are fine exemplifications of the facilities afforded to the artist by these materials. These stones will be more particularly described under Mineral Manufactures.

Machine Carvings (80).—The screen, and the various specimens of carving appended to it, are the result of a machine invented by Mr. Thomas Jordan, and known as Jordan's Patent. The great advantages of the machine are, that an exact fac-simile of the original is produced, with any extent of under-cutting, and that several copies can be produced by one operation. It is difficult to describe without the aid of drawings the principles upon which this depends ; but the following description by the inventor, communicated to the Society of Arts, appears sufficiently clear and explicit to convey a tolerable idea of this ingenious invention, which has been for some time in active operation.

The machine consists of two parts, each having its own peculiar movement quite independent of the other, but each capable of acting simultaneously and in unison with the other. The first, or horizontal part, is the bed-plate and floating table, on which the work and the pattern are fixed, and all the motions of which are horizontal. The second, or vertical part, is that which carries the tracing and cutting tools, the only motion of which, except the revolution of the cutters, is vertical. Let us now suppose that we have an horizontal table, capable of moving about in every possible manner in its own plane, and that we have a point over that table capable of moving in a vertical line only. If the point remains fixed, and in contact with the table while moving over various curves and right lines, lines corresponding with these movements will be

described on the table, in the same manner as they would have been had the table been fixed and the point moved; but if, while these horizontal movements are going on, we add the vertical movement of the point, we then trace a solid figure, which has for its plane the outline described by the horizontal motion of the table, and for its elevation the outline described by the vertical motion of the point. This may be better illustrated by taking any simple solid form, and moving it horizontally, while it is traced by a point moving vertically.

The Slab of Honduras Mahogany (135) is remarkable as an illustration of the enormous size to which the mahogany-tree grows. This tree is of rapid growth, and its trunk commonly attains to a diameter of four feet. Mahogany-cutting constitutes a principal occupation of the British settlers in Honduras. Gangs of negroes, consisting of from ten to fifty each, are employed in this work—one of their number being styled the huntsman, and his duty is to traverse the woods in search of the trees. When these have been discovered, a stage is erected against each so high that the tree may be cut down at about twelve feet from the ground. After the branches are lopped, the task commences of conveying the logs to the water-side, which is often a work of considerable difficulty. They then float down the current singly, till they are stopped by cables which are purposely stretched across the river at some distance below. Here the different gangs select their own logs, and form them into separate rafts, preparatory to their final destination. In some instances, the profits of this business have been very great, and a single tree has sometimes been known to have produced 1,000*l*. Mahogany is said to have been introduced into Britain about the year 1724.

The Chemical Collection in the Nave is of much interest, as exhibiting the results of crystallization on a large scale. Amidst the masses of spermaceti, alum, and sulphate of copper, exhibited in this group, will be found some beau-

tiful examples of crystalline form; such, indeed, as could not be obtained except where the operations have been carried on upon the gigantic scale of the chemical works of the exhibitors, Messrs. Pattinson, Hatmel and Ellis, Miller and Sons, and Maberley. As these preparations form a feature in the Chemical Section, the notice of their manufacture is reserved for that part.

Patent Pressure Filter and Fountain.—The Building being supplied with water from the main, and thus a high pressure easily attainable, the advantages of this filter are sufficiently shown. It consists of a hollow sphere of sandstone, which is placed in another sphere of iron: this iron ball is connected with the main, and the water is by the pressure forced into the interior of the sandstone sphere, being filtered in its passage through the interstices of the stone. Connected with the interior sphere is a pipe through which the filtered water flows out. The water between the two spheres, as it gets foul by the accumulation of impurities, is drawn off by another orifice, and thus the sandstone is cleaned as often as may be requisite.

Passing over for the present any description of the beautiful examples of manufacture from the papier maché capital to the Colebrook-dale rustic dome, all of which will be noticed in the proper place, the lighthouse arrangements claim attention.

Catadioptric Apparatus for Lighthouses (157).—*Catoptrics* relates to the reflexion of light from plane or curved surfaces, and *Dioptrics* to the refraction of light in passing through lenses or other transparent media.

"There can be little doubt," says Mr. Alan Stevenson, in his treatise on Lighthouses, "that down to a very late period the only mode of illumination adopted in lighthouses, even in the most civilized nations in Europe, was the combustion of wood or coal in *chauffers* on the top of high towers or hills."

So lately as 1816 the Isle of May light, in the Frith of Forth, was of this rude description, and had been a coal

fire for 181 years. For about 40 years after its erection by the great engineer John Smeaton, the *Eddystone* showed no better light than a few miserable tallow candles.

So lately as 1801, the light at Harwich, in addition to the coal fire, had *a flat plate of rough brass on the landward side*, to serve as a reflector. Such methods were most imperfect in every respect.

In recent times, improvements have rapidly succeeded each other. First, the *sources of light* were nearly perfected by the adoption of Argand's oil lamps. Next, the true principles of reflecting, or *catoptric* lights, were applied to Argand's lamps. By this natural but important combination very efficient sea-lights were put into many lighthouses. The progress was by gigantic strides, under the guidance of Fresnel, and Robert Stevenson of Edinburgh.

The oil, the wicks, the lamps, the reflectors, successively received the attention of men of skill and science, with the best results in the efficiency and economy of the lights.

Some idea of the perfection to which the shaping and polishing of *parabolic reflectors* have been brought, may be formed from the parabolic reflector exhibited by W. C. Wilkins of Long Acre.

The arrangement of lights on the *catoptric* system has been even recently improved, as we shall have another opportunity of describing; but the *dioptric* and *catadioptric* systems of *preventing loss of light*, for directing the greatest possible amount of light towards the horizon, have for some years been adopted for the more important sea-lights of great maritime nations.

The two great lighthouses exhibited are examples of these improved. They are termed of the "*first order*," that is to say, they are of the largest dimensions employed in lighthouses.

The object to be obtained by the use of *lenses* in a lighthouse is the same as that obtained by the use of reflectors. Each apparatus effects the same result by different means, collecting the rays which diverge from a point, called

the focus, and projecting them forward in a beam, the axis of which coincides with the produced axis of the instrument.

In the case of *reflection*, this result is obtained by the light being *thrown back* from a surface formed into a parabolic shape, which causes all the rays to proceed in one and the same direction. In the case of *refraction*, on the other hand, the rays pass through the refracting medium, and are *bent* or *refracted* from their natural course into that desired.

The names of Buffon, Condorcet, and Brewster are conspicuous in the history of the dioptric system; but to Auguste Fresnel is due the merit of having first constructed this apparatus on true principles, and of finally applying it to the practical purposes of a lighthouse.

The Dutch were the first to follow the French, and the Northern Lights Commissioners were the next, and then the Trinity House, and now all maritime nations are adopting this important improvement.

The manufacture of such masses of pure glass as are required is a matter of great difficulty. The difficulties are of two kinds—first, to get the glass free from *striæ* or flaws, and, secondly, to get a colourless glass. The facilities for making crown-glass free from striæ determined Fresnel in the adoption of the material of the lenses of his first dioptric apparatus, notwithstanding the *greenish colour* which it invariably has, and which is very marked when the light passes through a great thickness, as happens when we see the the lenses of these apparatus sideways.

In both the arrangements exhibited, crown-glass has been employed.

The catadioptric part of the apparatus—the combination of reflection and refraction—is in the upper part or dome of the apparatus. This important improvement is due to Mr. Alan Stevenson of Edinburgh. The illuminating effect of the Cupola of Jones is to that of the mirror formerly used as 140 to 87.

Astronomical Telescope (254), with its object-glass of 11¾ inches diameter, with equatorial movements and other adjustments, well displays the magnificent kind of instruments which are required for penetrating into space. The difficulty of obtaining large lenses is very great. Under the immediate inspection of Fraunhoffer of Munich they were brought to a high degree of perfection; but in this country until the present time they have not been satisfactorily produced. The first difficulty is that of obtaining glass sufficiently free from striæ to give a well-defined magnified image of a point of light; and the second is that of grinding and polishing, which require the utmost mathematical precision. The grinding is effected by brass tools of various kinds, corresponding with the required curvature; and about six sizes of washed emery are employed for grinding the lens to the true figure, which is called *tracing* the lens, the grinding with every size emery being continued until all the marks made by the previous size are removed; the polishing being completed with putty powder shaken uniformly over cloth and moistened with a little water, which is then worked into the cloth with a brass convex tool. This operation is so important, that it is often a task of from two to three hours to make up a polisher of from eight or nine inches diameter. Mr Ross's other apparatus spread around this will receive notice in their proper groups.

Model of Britannia Bridge.—It may be stated that the tubes of the Britannia and Conway Bridges are formed of iron plates riveted together. The whole of the riveting was done by hand, and 1,095,050 rivets were employed in each tube.

The entire bridge, including both lines, contains nearly a million and a half cubic feet, or 105,000 tons of masonry, 44,200 cubic feet, or 9,480 tons of cast iron. The two tubes in their complete state contain 9,360 tons of wrought iron, 1,015 tons of cast iron, and 165 tons of permanent way. They are composed of about 186,000 separate pieces

of iron, pierced by seven millions of holes, and united by upwards of two millions of rivets. They contain 435,700 feet, or 83 miles of angle iron; and their total weight is 10,540 tons.

This enormous mass has been raised 103 feet, where it rests upon its towers, the span between them being 460 feet. When we know that the span of the centre arch of Southwark Bridge is but 240 feet, the enormous space over which this hollow iron beam is extended, is faithfully conveyed to the mind.

The other models of the wrought-iron bridges over the Wye, at Chepstow, by Mr. Brunel, which is the first of the kind constructed, and of the bar-chain suspension-bridge at Kieff, across the river Dnieper, in Russia, by Mr. Vignoles, are well deserving inspection, as illustrations of engineering skill.

Model of 3,000 miles of Northern England (90) very clearly shows the peculiar features of that section of our island, extending over portions of Leicestershire, Yorkshire, Nottinghamshire, Derbyshire, Cheshire, and Lancashire.

Trigonometrical Model of the Undercliffe, Isle of Wight. —In this model, Captain Ibbetson has not merely shown the topographical features of the part of the island represented, but has also exhibited the geology of the line of coast. In the sections of the cliffs the succession of strata is beautifully displayed; various divisions of the lower greensand are seen capping the Wealden strata, which are the lowest beds exposed. The lower greensand is capped in turn by the gault; and then succeed the upper greensand, the chalk marl and the chalk forming the highest portion of the ground modelled. As there are many considerable disturbances displacing and dislocating the strata within the area selected, very curious geological phenomena are exposed in a highly-instructive manner. The influence of the mineral character of the different strata in determining the outline of the land is finely seen.

Limestone Model of Plymouth Breakwater.—This model conveys a good idea of this great national work.

The Breakwater is an insulated mole, or vast heap of stones, stretching across the entrance to the Sound, so far as to leave a passage for vessels at either end, and opposing a barrier to the heavy swell rolling in from the Atlantic. Its length is 1,760 yards, the eastern extremity being about 60 fathoms to the eastward of St. Carlos's Rocks, and the western 300 west of the Shovel Rock. The middle part is continued in a straight line 1,000 yards, and the two extremities incline towards the northern side of the straight part in an angle of about 120 degrees. This great work was begun August 12, 1812. During its progress convincing proofs of its efficacy and utility were afforded. The expense of erecting the Breakwater is estimated at 1,171,100*l.*

Near this is another model showing the manner in which the lighthouse built at one end of the Breakwater has been constructed. It will be seen that the granite blocks of which it is built are so accurately dovetailed as to render it impossible to move one stone without the whole; in fact, the building is as secure as if it had been constructed from a solid rock. These models are made from the same limestone as is used in the Breakwater itself.

The models, &c., which occur at the western end of the Nave, are in themselves sufficiently explanatory, or they will be noticed under the Class to which they especially belong.

Outside the Building, West End, North.

Within this space are gathered a collection of such things as could not be well placed in the Building. These are, however, in many respects of the utmost importance, and attention should be directed to some of their characteristics.

As the groups to which many of these things belong

will receive especial notice which must lead to their being named in connection with them, it will be unnecessary to do more in this place than to describe such peculiarities as require description on the spot.

The Atmospheric Recorder of Dollond appears to be one of these. Meteorological observations are now receiving a large amount of attention, and it is of the utmost importance to render all the instruments self registering. By a very ingenious arrangement, the barometer and thermometer are made to register every variation of temperature and atmospheric pressure. The dryness and moisture of the air are also indicated; the material employed as the hygrometric agent being in this case a slip of mahogany cut across the grain. It may be explained, that wood, straw, paper, and particularly long human hair, contract by losing moisture as the air becomes dry, and expand, by absorbing it, as the atmosphere becomes charged with aqueous vapour—thus affording very good hygrometric measurers. It will be easily understood, that, by an adjustment with a lever, a small change in length at one end may be made to indicate a large one at the other; and by moving a pencil over a paper also moving, mark every change. An electrometer, a rain-gauge, and an evaporator to indicate the rate at which moisture is carried off from the earth's surface, are also connected with this apparatus; and the direction and force of the wind are constantly recorded. A description and drawing of the Atmospheric Recorder, which are attached to the machine, will fully explain its construction. It should be remembered, that Whewell, Follett Osler, and some others, have also some very ingenious arrangements for determining many of the points in meteorology which are combined in this apparatus of Dollond.

The Admiralty Anchors (Exhibitors 55, 57, 58), and those constructed upon Rogers's patent plan, with the chain cables, are instructive examples of the principles upon

which a sufficient hold is insured upon any anchorage ground to resist the strain exerted by a large ship heaving upon the waters. The chief point in Rogers's anchor, upon which the patentee rests his claims, appears to be founded upon the wedge-like principle involved in their construction, by which a firmer hold is taken of the ground as the strain increases.

Granite Columns and Obelisks. (Exhibitors 14, 54, 75.)—These are very fine examples of this most durable stone. The column is from the Cheesewring Granite Quarries, near Liskeard, which are the property of the Duke of Cornwall. Although there exists here a very extensive area of granite of the purest quality, it has not, until lately, been much worked, owing to the difficulties of transport. The proximity of a railroad, however, has now rendered this available, and it is worked by a Company under a lease from the Duchy of Cornwall. It appears that 15,000 tons of the finest granite can be quarried annually, and the blocks are of unusually large size. The block from which the shaft of the column has been cut, weighed, when removed from the quarry, more than 400 tons; it measured 35 feet in length, and 4 feet 6 inches in width, containing 5,040 feet cube. The dimensions of this specimen as worked are—

Pedestal.

	Ft.	In.		Ft.	In.	
Base	4	2	square	2	2	high
Die	3	4	,,	3	8	,,
Cap	4	4	,,	0	11	,,

Column.

Base	3	4	square	1	4	high
Shaft	2	8	,,	20	0	,,
Capital . .	3	8	,,	1	4	,,
Total Height . .				29	5	

The obelisk from Penryn, Cornwall, is from the Carnseu

CONTENTS.

All our coal has resulted from vegetable life. That carbon which we now employ as our ordinary fuel once floated in the atmosphere as invisible carbonic acid: plants, resembling, in many respects, those which now belong to the great deltas and swamps of the tropics, absorbed this as their natural food. Under the influence of sunlight, which excited the vital powers of the plants, this carbonic acid was decomposed, the carbon was retained to form the woody matter of the plant, and the oxygen set free for the use of higher organizations. The plants of the coal formations, of which no fewer than 300 species have been enumerated, are well described by Dr. Joseph Hooker, in the 2nd vol. of the "Memoirs of the Geological Survey." The following quotation from Dr. Hooker's memoir should be read at the base of the column of thick coal, as explaining in the most lucid manner its formation, while the example of a fossil tree from the coal measures exhibited here by Cruttwell, Allies, & Co. (52), and the fossil coal plants and ironstones in Class 1, will form satisfactory illustrations:—

"The consequence of the existence of the coal plants has been the formation of coal, but how this operation was conducted is a question still unsolved. The under-clay or soil upon which the coal rests, and upon which some of the plants grew, seems, in general, to have suffered little change thereby, further than what was effected by the intrusion of a vast number of roots throughout its mass. The shales, on the other hand, are composed of inorganic matter, materially altered by the presence of the vegetable matter which they contain. The iron-clays again present a third modification of this mixture of organic and inorganic matter, often occurring in the form of nodules. These nodules seem to be the result of a peculiar action of vegetable matter upon water charged with soil and a salt of iron. The ironstone nodules of existing peat-bogs appearing altogether analogous to those of the carboniferous period, whether in form or in chemical constituents.

Here, then, the botanist recognises in one coal-seam a vegetable detritus, under three distinct phases, and which has been acted upon in each by very different causes. In the under-clay there are roots only: these permeate its mass, as those of the water-lily and other aquatic plants do the silt at the bottom of still waters. The coal is the detritus either of those plants, whose roots are preserved in the under-clay, or of those, together with others which may have grown amongst them, or at a distance, and have been afterwards drifted to the same position. Above the coal is the third soil, bearing evidence of the action of a vigorous vegetation: this is the shale which has all the appearance of a quiet deposit from water charged with mineral matter, and into which broken pieces of plants have fallen. Here there is so clear a divisional line between the coal and shale, that it is still a disputed point whether the plants contained in the latter actually grew upon the former, or were drifted to that position in the fluid which deposited the mineral matter. Amongst the shales are also interspersed, in many cases, innumerable stumps of *Sigillariæ* similar to those whose roots occur in the under-clay, and which are themselves found attached to those roots in soils similar to the under-clay, but unconnected with any seam of coal. These stumps are almost universally erect, are uniformly scattered over the seams, and otherwise appear to have decidedly grown on the surface of the coal: the shales likewise seem deposited between these stumps. The rarity of *Sigillariæ* roots (*Stigmariæ*) in this position is probably due to their being incorporated with the coal itself, though they sometimes occur above that mineral, and between the layers of shale. The seams of ironstone, or black-band, are the last modifications of soil by vegetable matter to which allusion has been made: when these are uniform beds, or layers, they may be supposed to be the deposit from water charged with iron and soil which has percolated through the peat, and, in so doing, absorbed a great deal of vegetable matter.

The layers of nodular ironstone are simple modifications of these, and may be caused by the sedimentary particles contained in the fluid, which, instead of being deposited in a uniform stratum, are aggregated round broken bits of vegetable matter (as fern, leaves, stems, or cones), which served as nuclei."

The principal coal-fields of Great Britain are situated in Northumberland, Durham, Cumberland, Yorkshire, Louth, Scotland, Staffordshire, Warwickshire, Somersetshire, Gloucestershire, South Wales, and Flintshire. This last district has only been worked within the last thirty years, but the mines are now most productive. Of No. 34 alone 2,000 tons per week are raised, and exported chiefly to foreign countries from Birkenhead.

Cement and Concretes, and Cement Stones. (Exhibitors 2, 3, 4, 5, 7, 10, 11, 19, 25, 27.)—Vicat's work on cements, translated by Captain Smyth, and the publications by General Sir C. W. Pasley, should be consulted as affording the most information on these subjects, to those who may be desirous of learning the peculiar properties of the various kinds employed.

The cements mostly used in building are composed of lime and sand. The hydrate of lime—that is, lime which has been recently slacked, in which process a quantity of water is absorbed—is mixed with silicious sand, and used without delay, before it has time to imbibe carbonic acid from the atmosphere. The lime adheres and unites the particles of the sand, and, by the operation of the molecular forces, the adhesion of the particles is constantly increasing. The examples of cement furnished by Messrs. Francis & Sons are united by the so-called "Roman" cement and the Portland cement, in the last of which, two bushels only of the cement are mixed with 37 bushels of shingle, which was fit for removal in about three weeks after mixture: the illustrations also by White & Sons, of the strength of cements, may be instructively examined. Hydraulic limes are composed of carbonate of lime; silica

and alumina, and the argillaceous limestones, are employed in their preparation. Of this kind are the *puzzolana* from Italy, and the *trass* from the Rhine. The blue lias limestones are considered the strongest *water limes* in this country. They are found on opposite sides of the Bristol Channel, at Watchet in Somersetshire, Aberthau in Glamorganshire, and Lyme Regis in Dorsetshire, and they are now worked largely in Worcestershire. Near Stratford-on-Avon a peculiar *cement-clay* is found which is associated with the lias limestone in the manufacture of the lias cements. The lias limestone is sometimes mixed with ordinary lime, and sometimes with Portland cement, according to the purposes to which it is intended to be applied. Many examples of these will be found in the collection No. 7.

The discovery of the use of concrete is curious. In excavating for one of the piers of Waterloo Bridge, the workmen had a good deal of difficulty, owing to the very compact state of the gravel forming the bed of the river, which everywhere else they had found perfectly loose. This effect had been produced by the accidental sinking of a barge-load of lime over that spot some time before, which had cemented the loose gravel into a solid mass, resembling the calcareous conglomerates of nature, which are gradually formed by a similar process. Mr. Rennie having mentioned this circumstance to Sir Robert (then Mr.) Smirke, the latter with great judgment availed himself of the hint, and subsequently used it in all his foundations, none of which have ever been known to fail. Part of the Penitentiary at Millbank, begun by another architect in a different manner, before Sir Robert Smirke was employed there, was evidently giving way. The superior efficiency of concrete was also proved in a remarkable manner at the new Custom-house, where the floor of the large apartment, called the Long Room, actually fell in, and the whole building was in danger, owing to the insufficient

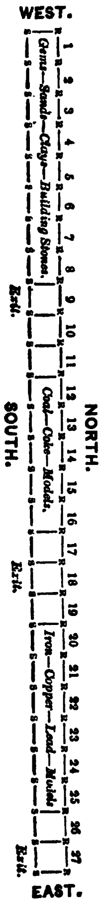
manner in which the piling had been originally executed in a very difficult situation. At this period, Sir Robert Smirke was consulted, who found it necessary to pull down a small part of the building, but saved the rest of it by undersetting all the walls with concrete, to the average width of 12 feet, and to the depth of from 12 to 15 feet—that is, until he found a natural bed of gravel, including one course of Yorkshire landing stones, and twelve courses of bricks laid in cement, having three offsets or footings between the Yorkshire landings, resting on the concrete and the base of the original walls. No other expedient could possibly have saved this fine edifice from entire demolition. It must be allowed, that not only the ancient Romans, and after them the Moors, but even the Norman barons of England in their feudal castles used concrete, of which Kendal Castle is one of the most striking examples; and more recently, Belidor in his "Architecture Hydraulique," treats of Beton mortar, which is much the same; so that is not absolutely new. In fact, according to the old proverb, there is scarcely anything new under the sun; but the merit of introducing this immense improvement systematically and generally into the modern practice of architecture, is unoubtedly due to Sir Robert Smirke. (*Pasley.*)

Some other examples of the operations of cements will be found in Class 1, and the artificial stones, encaustic, Parian cement, &c. will be described in that Section.

Gypsum (4) is a sulphate of lime; it occurs in various conditions, both amorphous and crystalline. It is found in all parts of Europe; and when burnt it is known by the name of plaster of Paris; from the circumstance that large deposits of plaster exists near that city.

Several examples of the Welsh, Cornish, Scotch, and Irish, and other *slates and flags*, are exhibited here, together with the various *sand and grit stones* which are employed for abrading or polishing.

A variety of *road-stones* will also be found in this department, principally the greenstones and elvans in their different varieties: these have been sent from Cornwall, Ireland, and some other districts. The hard and rough trappean rocks, associated with the grauwacke of Cornwall, form the best road material in the county. Greenstone has been shipped from various ports in Cornwall to London, and is found to answer admirably in those thoroughfares where the traffic is great, it is so tough and hard. *The Elvans*, well selected, form admirable road materials, but they are very unequal in their character. Many examples of other rocks, as the Cornish serpentine, Welsh limestones from Abergele, and marbles from Ireland, show the peculiarities of many of our geological formations.



Class I.—Mining, Quarrying, Metallurgical Operations, and Mineral Products.

Situation of Class.—*Near the Southern Wall of the Building, occupying the space between the Western End and the Exit Door adjoining the British Sculpture Room. Between Pillars* R. *and* S. *from* 1 *to* 27.

Position of Groups (Numbers referring to Pillars).—Crystals, Gems, Ornamental Stones; Models of Crystals, and Educational Collections; Fossils, &c., 1 and 2.—Salt; Mineral Manures; Soils, Sand, Plumbago, to 4.—Potters' Clays and Cements, to 6.—Granites, Marbles, Slates, to 9.—Coal, Coke, Peat, to 14.—Iron Ores, Manufactured Iron, Models, &c., to 18.—Models of Coal Mines, Copper Ore, Dressing Machine, Zinced Iron, Zinc, Tin Smelting, to 21.—Copper, Tin, and Iron Ores; Models, Tools, &c., to 24.—Platinum, Cobalt, Gold, Silver, Lead; Metallurgical Processes, &c., to 26.

Gems and Ornamental Stones (Exhibitors 2, 3, 4, 10, 11, 15, 16, 19, 20, 22, 24, 25, 28, 31) and the *Koh-i-Noor.*—The crystals of diamond here exhibited are instructive as showing the way in which diamonds are found mixed with silicious pebbles, grains of gold, oxide of iron, &c. The specimen exhibited is from the Duke of Buckingham's collection, and is figured in Mawe's "Treatise on Diamonds and Precious Stones." The models of the largest diamonds known are associated with this. In connection with the more brilliant collections found in other parts of the exhibition, any historical notices will be more appropriately appended. A few remarks may, however, be introduced on the mode of occurrence and the physical constitution of this beautiful gem.

Brazil supplies Europe with the largest number of diamonds, the oriental diamond beds appear-

ing to be nearly exhausted. The diamonds of India were principally found in the kingdoms of Golconda and Viziapour: those of Brazil, discovered in the seventeenth century, and at first used as card-counters, are found in the district of Serro-do-Frio, in a conglomerate called *cascalho*, from which they are extracted by washing. Diamonds are always found crystallized, and they are so hard that they can only be abraded by rubbing one against another; hence the process of cutting and polishing is effected by means of finer diamond powder. The weight and value of diamonds are estimated in carats, one of which is equal to 3·174 grains troy; and the price of one diamond compared with another of equal colour, transparency, and purity, is as the square of the respective weights. In valuing diamonds, either rough or cut, the practice is to take the weights in carats, to square that weight, and then to multiply the product by such a rate of price as may correspond to the state and quality of the stone; thus, if a natural crystal of diamond be clear, without flaws, and of a favourable shape, the price by which the square of its weight should be multiplied is 2*l.*; so that if the stone weigh 1 carat, its value will be 2*l.*; if 2 carats, $2 \times 2 = 4$, and $4 \times 2 = 8$, or a stone of 2 carats is worth 8*l.* A stone of 10 carats, in the same way, will give $10 \times 10 = 100$, and $100 \times 2 =$ 200*l.*, the value of a perfect rough diamond of this weight. The diamond, as Sir Isaac Newton conjectured from its high refracting power, is a combustible body. The researches of Lavoisier, and others, have shown that this gem is nothing more than pure carbon, and under the influence of the voltaic battery diamonds have recently been converted into coke. The plumbago, which is in the adjoining bay, and the coke but a short distance from it, differ only in physical condition; in chemical constitution they are similar to the diamond. *The Koh-i-Noor* diamond is to the east of the Transept, but it is thought the following account of it may be introduced in this place.

The diamond denominated the Koh-i-Noor, or Mountain (koh) of Light (noor), has long enjoyed both Indian and European celebrity, and has accordingly been the subject of traditionary fable, as well as of historical record.

According to Hindu legend, it was found in the mines of the south of India in the days of the Great War, the subject of the heroic poem, the *Maha'bha'rata*, and was worn by one of the warriors who was slain on that occasion, Karna, king of Anga: this would place it about four thousand years ago, or 3001 B.C. A long interval next makes it the property of Vikramaditya, the raja of Mjayin, 56 B.C., from whom it descended to his successors, the rajahs of Malwa, until the principality was subverted by Mohamedan conquerors, into whose hands it fell, with other spoils of infinite value.

Whatever may be thought of the legend which gives so high an antiquity to the Koh-i-Noor, we might expect some more trustworthy information when we come down so low as the beginning of the fourteenth century; Malwa having been invaded and overrun by the armies of Ala-ad-din, the sultan of Delhi, in 1306, who, according to the autobiography of the sultan Baber, acquired the jewel. That it did become the property of the sultanas of Delhi is little doubtful, but when or how is matter of some uncertainty, although the grounds of the difficulty have not hitherto been investigated.

In 1665 Mons. Jean Baptiste Tavernier, an enterprising and intelligent traveller, and an eminent jeweller, although Ecuyer, Baron d'Aubonne, visited India especially to purchase diamonds. His profession and his personal character seem to have recommended him to the favourable attention of the nobles of the court of Delhi, and bigot as he was, of Aurangzeb himself, by whose commands Mons. Tavernier was permitted to inspect and handle and weigh the jewels of the imperial cabinet. Amongst them was one which far surpassed all the rest in size and value. Tavernier describes it as rose-cut, of the shape of an egg cut in

two, of good water, and weighing 319½ *ratis*, which, he says, is equal to 280 of our carats.

There is but little doubt that the diamond examined by Tavernier, in the Delhi Cabinet, was the Koh-i-Noor. Baber, the Mogul emperor, obtained a diamond, corresponding exactly with this, and it passed eventually into the possession of the ruling family of Kabul. Nadir Shah, on his occupation of Delhi in 1739, compelled Mohammed Shah, the great-grandson of Aurangzeb, to give up to him everything of value that the imperial treasury possessed, and his biographer and secretary specifies a *peshkash*, or present, by Mohammed Shah to his conqueror of several magnificent diamonds. According to the family and popular tradition Mohammed Shah wore the Koh-i-Noor in front of his turban at his interview with his conqueror, who insisted on exchanging turbans in proof of his regard. However this might have been, we need have little doubt that the great diamond of Aurangzeb, was in the possession of Mohammed Shah at the time of the Persian invasion; and if it was, it most certainly changed masters, and became, as is universally asserted, the property of Nadir Shah, who is also said to have bestowed upon it the name of Koh-i-Noor. After his death, the diamond which he had wrested from the unfortunate representative of the house of Timur, became the property of Ahmed Shah, the founder of the Abdali dynasty of Kabul, having been given to him, or more probably taken by him, from Shahrikh, the young son of Nadir. The jewel descended to the successors of Ahmed Shah, and when Mr. Elphinstone was at Peshawur, was worn by Shah Shuja on his arm. When Shah Shuja was driven from Kabul, he became the nominal guest and actual prisoner of Runjet Sing, who spared neither importunity nor menace, until, in 1813, he compelled the fugitive monarch to resign the precious gem, presenting him on the occasion, it said, with a lakh and twenty-five thousand rupees, or about twelve thousand pounds sterling. According to Shah Shuja's own account, however, he assigned to

him the revenues of three villages, not one rupee of which he ever realized. Runjet was highly elated by the acquisition of the diamond, and wore it as an armlet at all great festivals. When he was dying, an attempt was made by persons about him, to persuade him to make the diamond a present to Jagannuth, and it is said that he intimated assent by an inclination of his head. The treasurer, however, whose charge it was, refused to give it up without better warrant, and Runjet dying before a written order could be signed by him, the Koh-i-Noor was preserved for awhile for his successors. It was occasionally worn by Rhurreuk Sing and Shu Sing. After the murder of the latter, it remained in the Lahore treasury until the supercession of Dhulip Sing, and the annexation of the Punjaub by the British Government, when the civil authorities took possession of the Lahore treasury, under the stipulations previously made, that all the property of the state should be confiscated to the East India Company, in part payment of the debt due by the Lahore government and of the expenses of the war; it was at the same time stipulated that the Koh-i-Noor should be presented to the Queen of England. Such is the strange history of certainly one of the most extraordinary diamonds in the world. After the Company became possessed of the gem, it was taken in charge by Lord Dalhousie, and sent by him to England in custody of two officers.

Corundum.—Varieties of this stone, exhibiting the different colours, are in this collection. This name is the Indian term applied by the natives to a large variety of those gems. The sapphire, from the ancient Greek name "sappheiros," is the most valuable of the corundums. This stone is scarcely inferior in hardness to the diamond. It invariably occurs crystallized when found *in situ*; but it is often discovered in the beds of rivers as rounded pebbles, which, when broken, exhibit a very brilliant surface. These gems are compounds of alumina, lime, silica, and oxide of iron; and to the variations in quantity of the last sub-

stance, and probably to the different states in which it exists, we may attribute those conditions which are known as the blue and red sapphire, red oriental ruby, yellow topaz, and amethyst.

An emerald of unusual size, the property of the Duke of Devonshire, is in this case; and against the wall are emeralds in the matrix, from the mine of Muso, New Granada: this gem is a compound of glucina, silica, and alumina. Other precious stones of the same general character are here: the beryl, topaz, garnet, precious opal, zircon, and spinel.

Ornamental Stones.—These consist of stones of less value, which are extensively used in the cheaper kinds of jewellery, viz., rock crystal, amethyst, calcedony, cairngorm, rose quartz, aventurine. The flints from Wilts are interesting from the various organic remains enclosed in them: these are found widely distributed through the chalk of England. Jaspers, bloodstone, sunstone, cats-eye, moonstone, sumachelli marble, rose manganese, chert, mochostone, malachite, amber, are in second part of case.

Transparent carbonate of lime, showing double refraction, from Iceland, with tourmalines, arragonite, &c., for optical purposes. The phenomena of double refraction are among the most curious of physical optics: they would appear to be due to some peculiar molecular arrangement, by which the beam of light is divided in its passage through the crystal into two lines: a similar result can be produced by looking at any object through two transparent layers of unequal density. The tourmaline, which is a compound of soda, potash, silica, alumina, oxide of iron, magnesia, and boracic acid, has the remarkable property of altering the condition of a ray of light, so that it presents many novel physical effects: these are included under the very beautiful class of phenomena known as the polarization of light.

Agates. (Exhibitors 10, 22.)—These are some of the numerous forms under which silica (flint) presents itself in

nature. An impression commonly prevails that agates are the result of a silicification of wood. We frequently find masses of petrified wood, in which the flint has replaced the woody particles in such a manner that they much resemble the layers in the agates. These stones are, however, commonly met with in the trap-rocks, particularly those called Amygdaloid, forming nodules. The silicious particles have often arranged themselves in thin layers parallel to the external surface of the nodule; sometimes it is not solid, but has a hollow space, which is studded with crystals of quartz, and sometimes with carbonate of lime. The formation of these nodules appears to depend upon the operation of peculiar forces acting from the surface, and thus occasioning the accretion of particles, layer after layer. In all cases there has been a nucleus on which the layers commenced; but since the greatest number and the finest agates are found in rocks of igneous origin, we cannot accept the theory which refers their formation to the petrifaction of vegetable matter.

The Turquoises, in the matrix (20) and manufactured, should not be passed by. They are composed of silica, oxide of copper, and oxide of iron. The specimens were collected in a new locality in Arabia Petræa. They are very interesting, on account of showing the manner of occurrence of this beautiful mineral, which is seen in these examples to assume botryoidal forms, and to occur also disseminated, and in concretionary layers, in a ferruginous sandstone.

Of the discovery of these turquoises, Major Macdonald has favoured us with the following interesting statement:—

"In the year 1849, during my travels in Arabia in search of antiquities, I was led to examine a very lofty range of mountains composed of iron sandstone, many days' journey in the desert; and whilst descending a mountain of about 6,000 feet high by a deep and precipitate gorge, which in the winter-time served to carry off the water, I found a bed of gravel, where I perceived a

great many small blue objects mixed with the other stones: on collecting them, I found they were turquoises of the finest colour and quality. On continuing my researches through the entire range of mountains, I discovered many valuable deposits of the same stones, some quite pure, like pebbles, and others in the matrix. Sometimes they are found in nodules varying in size from a pin's head to a hazel-nut; and when in this formation they are usually of the finest quality and colour. The action of the weather gradually loosens them from the rock, and they are rolled into the ravines, and, in the winter season, mixed up by the torrents with beds of gravel, where they are found. Another formation is, where they appear in veins, and sometimes of such a size as to be of immense value. They also occur in a soft yellow sandstone, enclosed in the centre, and of a surpassing brilliancy of colour. Another very curious formation is where they are combined with innumerable small coloured quartz crystals, and which has the appearance of a mass of sand, small pebbles, and turquoise, all firmly cemented together. This formation is one of the most peculiar in the whole collection."

Educational Collection. (Exhibitors 8, 9, 14.)—The collections of minerals and fossils, to illustrate the recent works on mineralogy, are of this class, for which purpose arrangements of this kind are eminently useful. Mr. Mitchell's models of the primary and secondary forms of crystals are well adapted to instruct in the rules which nature observes in producing the various groups of crystals. The gradual accretion of particles which occurs in the production of crystalline form, seems to indicate the action of some such force as that of magnetism in determining the position of each particle; and, indeed, the researches of Faraday and Pluker appear to confirm this view.

Dr. Leeson's exquisitely constructed *glass models of crystals* are of a far higher character. They are intended to illustrate a new system of crystallography, which is

based upon the hypothesis that all forms may result from a cube as the primary. These should be very attentively considered by all who desire to study this very beautiful branch of physics.

Although not a production of the mineral kingdom, we find here an object of interest in the following—

Case of Pearls found in the deepest part of the river Strules at the town of Omagh, Ireland. (15.)—These pearls are procured from a species of fresh-water mussel, the *Unio margaritiferus*, a shell not uncommon in Ireland, Scotland, and Wales, and in the mountainous districts of England. They are often of great beauty and considerable value, but are rare, since not above one mussel in a hundred contains a pearl, and not one pearl in a hundred is of good quality. One of these pearls has been found of the diameter of half an inch. There have been instances of individual Irish pearls fetching as much as forty, fifty, and more pounds. The pearl-mussel lives usually in rapidly flowing streams, and is found in Norway, Sweden, and other mountainous parts of Europe, as well as in Britain.

Native Sulphur from Sicily. (23.)—This peculiar elementary body is usually found in the neighbourhood of active volcanos or in volcanic districts. The quantity exported from Sicily, and employed in this country for the formation of oil of vitriol, which is sulphur combined with oxygen, is very large. At the time, however, that the king of Sicily sought to fix a high duty upon the sulphur of that island, attention was directed to our own pyrites, or sulphur ores. The sulphuret of iron of the Cornish mines, and also that of Wicklow, was then extensively worked, and the supply of sulphur from these sources has continued to be large, particularly from Ireland; from Ballyahan alone nearly 20,000 tons have been annually raised. These pyritic ores are subjected to a roasting process, by which the sulphur is combined with oxygen to form the sulphur acids, or in some cases the sulphurets are used directly for the manufacture of sulphate of soda

by combining them with salt previously to the roasting process.

Phosphoric Fossils—Artificial Manures, &c. (Exhibitors 35, 36, 37, 38, 41, 42, 46.)—The discovery by Professor Henslow of peculiar nodular concretions in the crag formations of Sussex has led to the manufacture of a manure of the most valuable character. These concretions, which were afterwards discovered by Mr. Paine in the greensand of Surrey, and the phosphoric earth, have, without doubt, been derived from the extinct animals inhabiting the seas under which the greensand deposits were formed. These, the collections of guanos, and of fish manure, which is termed normal guanuo, will be of interest to the agriculturist.

Fuller's Earth. (48.)—These deposits from Reigate scarcely require any description. The *Grey Stone Lime* (56), from the same district, is also well known. The fuller's earth occurs in regular beds near the summit of a hill, between beds of sand containing fossil wood and shells of the nautilus and other sea shells. Its peculiar property of absorbing oil is well known. It is a compound of silica, alumina, and water; its cleansing power depending on the alumina.

Rock Salt from Cheshire, &c. (Exhibitors 57, 58.)—This native chloride of sodium is obtained in Cheshire; and at Northwick, in that county, are some large works for purifying and crystallizing this useful product. By the evaporation of sea-water, salt, which is largely employed for curing fish, is also obtained. In Class 4 further information on the salt manufacture is given.

Minerals from Strontian. (55.)—The series of specimens exhibited by Sir J. M. Riddle, Bart., shows some of the characteristics of this district of Scotland. Both strontian, which takes its name from the locality in which it is found, and barytes, are important agents in the pyrotechnic art. Red fire owes its colour to the mixture of the nitrate

of strontian with some combustible material, and green fire is made by combining the salts of barytes with similar ingredients. Barytes is also largely employed for giving body to the inferior kinds of white lead, and the barytes white is itself a very pure pigment; but it can only be used under certain conditions, since it is liable to separate from the vehicle with which it may be mixed.

Plumbago—Black Lead—Pencil Manufacture. (Exhibitors 64, 65, 66, 67, 68.)—The Borrowdale mine, in Cumberland, as the only one in this country producing plumbago, or black lead, and that of a quality superior to almost any found in the world, requires a brief notice, from many of its peculiarities. It is situated nine miles from Keswick, on the steep side of a mountain, near the head of the valley of Borrowdale. The entrance to the mine is through a level, or *adit*, which was driven into the hill in 1798; but there are workings of a much older date than this. In the reign of James I., *the wad holes and wad commonly called black cawke, within the commons and wastes of Borrowdale*, were granted to William Whitmore and Jonas Verdon, *with liberty to dig, work, and carry away the same.* From that period to the present time, the Cumberland mine has continued to supply all the finest black lead; but the quantities produced have been exceedingly variable, owing to the irregular occurrence of the *bellies* or *sops*, as the nodular masses are locally called. In 1803 five hundred casks were produced from one mass, the value of the plumbago being 30*s*. a pound. In 1829 the proprietors obtained about half-a-dozen casks, weighing a hundred and a quarter each; and in 1833 a few casks more, which were worth 45*s*. a pound. Since that period the quantity obtained has not been large, but annually a few thousand pounds' worth have been sold. As will be seen, from the specimens exhibited, we now import plumbago from India, Ceylon, Greenland, Spain, Bohemia, and the Americas. Some small quantities have lately been found in the north of

Scotland. This peculiar substance is found by chemical analysis to contain, usually, in every 100 grains—

Carbon	88·37
Silica	5·10
Alumina	1·
Oxide of iron	3·6
Water	1·23

It will be evident from this that plumbago is only a form of carbon, the iron being an accidental mixture in very variable quantities.

The manufacture of pencils from natural black lead is a simple process. Selected pieces, scraped clean, are glued to a board, in order to fix them in the position for being cut, and they are then divided into slices by a fine saw. These slices are handed to a fitter, and placed in the grooves of the cedar-sticks prepared for the purpose. In a single pencil it often happens that as many as three or four pieces of plumbago are required; but each length is accurately fitted, so that there are no intervals, and then the other piece of cedar being glued on, the pencil is turned off, and being cleaned, is ready for use. Natural plumbago possesses different degrees of hardness, and consequently varieties of colour, but it is generally subjected to several operations to procure the range of colour and degrees of hardness required. Sometimes sulphur is combined with the plumbago, to produce the more intense degrees of blackness. Of late years the cheaper kinds of *black-lead* pencils have been made without a particle of that substance, antimony having been substituted for it.

Various processes have from time to time been introduced for the purpose of forming artificial masses of black lead. M. Conte, in 1795, was successful in combining plumbago with clay, and then calcining the mass, so as to produce crayons of any shade. In France, this process and a similar one by M. Humblot have been extensively employed, and crayons of other colours are also thus pre-

pared. The most important improvement has been, however, the patented process of Mr. Brockedon (65), which is as follows :—

Carefully-selected pieces of any size are ground in water, by an arrangement of rollers, to a most impalpable powder. This occupies a considerable time. This powder is then passed through sieves, the meshes of which are the smallest that can be made, as it is of the utmost importance that the particles should possess perfect uniformity. This prepared plumbago is now made up into small packets in paper contrived for the purpose, with a small hole upon one side, on which is fitted an adhesive wafer which acts as a valve. This is necessary, as previously to submitting the pulverulent mass to pressure, it is necessary that all the air which occupies the spaces between the particles should be removed. This is done by connecting each packet, by an elastic tube, with the exhausted receiver of a powerful air-pump. On opening the connection between them, the air is entirely withdrawn, and as soon as the force is removed, the little valve closes by the external pressure of the atmosphere, and the packet is fit for compression.

The square mass of powdered plumbago is now carefully fitted to a steel mould, into which a plug of steel exactly fits ; it is then subjected to the action of an enormous screw-press, from which it receives two blows giving a pressure equal to 5,000 tons. A solid mass thus results, which can be cut into any thickness by the pencil-maker ; every part of each mass being of exactly the same quality. Close examination shows that the particles have arranged themselves under the influence of the pressure in precisely the same manner as in the natural productions ; and if one of these compressed masses is broken, the fracture is exactly similar to that exhibited by a piece of native plumbago.

Sands. (Exhibitors 70 to 80-125.)—The silicious sands are employed in glass manufacture. Examples are exhibited for this purpose from Killomar and Cahir, in

Ireland, and some specimens of good quality from Sutton county and Donegal. From Reigate Heath, sand, which is employed to a considerable extent, is exhibited. The celebrated sands of Alum Bay, near the Needles in the Isle of Wight, are more largely employed than any other, and among the Class will be found some almost equally valuable sands from the neighbourhood of Aylesbury, together with specimens from Wareham, and from St. Austle, in Cornwall. In the manufacture of flint-glass, washed and burnt sand, peroxide of lead, carbonate of potash, and oxide of manganese, are employed.

The Isle of Wight sand is silica, 99·60; iron, 0·11; magnesia, 0·13; lime, a trace. A sand, lately introduced from the Wenham Lake (exhibited Class 24)—which consists of silica 99·53; iron, 0·03; magnesia, 0·04; lime, 0·14—promises to be of importance. There are some other districts producing sands of considerable value for various purposes; but so important is sand free of iron to the glassmakers, that it is brought to England even from so remote a land as New Holland.

China-clay, and other Clays. (Exhibitors 90 to 97, 100 to 104, 106 to 129.)—The porcelain earth of the granitic ranges of western England was first used in this country by Mr. Cookworthy of Plymouth, in 1768, who made hard porcelain with it at Plymouth; the manufacture being afterwards transferred to Bristol by Mr. Coster, and subsequently to Worcester. All our potteries are now supplied with this *kaolin;* the principal works being in the neighbourhood of St. Austle, in Cornwall, and on Dartmoor. This clay results from the decomposition of the felspar of the granite; and to render it fit for the potter it is subjected to the following process. The decomposed rock is broken up, and placed upon an inclined plane; water falling upon it washes out and carries away the clay with the smaller quartzose and micaceous particles: these are received in a "catch-pit," where the heavier matters are all deposited, while the clay suspended

in the water passes on into a second, and sometimes a third pit, in which it eventually subsides. When the tank is full, the clay is allowed to become solid; it is then cut into cubical pieces, placed under cover to dry, and being at last scraped and cleaned, is packed in casks, and forwarded to the potteries. The decomposed china-stone is employed as a glaze for china. The composition of the clay is—

Alumina	36·81
Silica	44·25
Lime, magnesia, and potash . .	2·20
Water	12·7

An inferior clay is much used by the papermakers and calico-bleachers. The clays found at Poole, and other parts near the coasts of Dorsetshire and Devonshire, are unfitted for the finer kinds of porcelain; but they are very extensively used in the manufacture of stoneware and common earthenware at Lambeth: 50,000 tons are shipped annually from Poole, 10,000 tons being for Lambeth. It is dug in square lumps of about 40 lbs. each, and transported to London in coasting vessels. When received by the potter, these lumps are, after being perfectly dried, ground to a powder, mixed with water, and after being allowed to remain sufficient time to become of uniform consistency, the mass is passed through pug-mills, and it is then fit for the operation of the workmen.

The Stourbridge Clay (91) has long been celebrated, and is extensively employed. The "Glass-house Pot Clay" is dug at a depth of 20 yards from the surface: it is found in beds about 4 feet thick; but only the middle part of the bed makes best clay, the remainder being called "seconds" and "offal;" three kinds of clay being obtained from one bed. The Stourbridge clay is known for standing the greatest heats of our furnaces; and hence it is used for glass-house pots, of which there is one exhibited; and the black clay raised from the "Whittamoor Mines," at Stourbridge, is used in the manufacture of melting-pots for steel

and other metals. These clays are peculiar to Stourbridge: they are found on the eastern side of the town, where a deposit exists which is spread over a space having a diameter of about two miles.

From Annery, near Bideford, very great quantities of clays are also produced, possessing peculiar characters, which render them useful in the potteries.

Cement Stones and Cements. (Exhibitors 99, 105, 130, 131, 177, &c.)—Attention has been already directed to these substances when examining the articles on the outside of the Building. But the collections of the cement stone and several works in cement, which have been executed at much cost on this South Wall, make this the fitting place for a brief description of these compositions.

The finer works exhibited have all a body of plaster of Paris. The Parian cement differs from all others in having borax—the borate of soda—in it. The plaster is mixed with a solution of borax, and after being again burnt it is re-ground for use. Martin's cement, of which a large work, introducing Thorwaldsen's groups, will be found opposite Pillars 21 and 22, is formed by grinding together gypsum (unburnt), alum, and pearl-ashes. Here we have a sulphate of potash and alumina acting as the hardening agent: to prevent any alkaline reaction a small quantity of muriatic acid is sometimes added. The manner in which these salts act in hardening the plaster is but little understood; but it is certain that an exceedingly small admixture of these chemical compounds with plaster gives it an extraordinary degree of coherence. The lias cement is so called from the circumstance of the lias limestone being burnt for the lime it contains.

Building and Ornamental Stones. (Exhibitors from 132 to 215 generally.)—To give any detailed account of these building and ornamental stones would occupy a far larger space than can possibly be spared in the present work. The specimens of granite and other primary rocks are

numerous. The granites and slates of Devon and Cornwall are well described in the Report of the Geological Survey of Devon and Cornwall, by Sir Henry De la Beche; and their localities may be studied on the geological map executed by the Survey on the opposite wall, in which the granitic masses are shown by the light lake colour. This map will serve also as a guide to nearly all the other rock formations here represented, and it may thus be used instructively in connection with the specimens exhibited. The oolites, freestones, and sandstones are best described in the Commissioners' Report on the Stones for the New Houses of Parliament. The applications of many of the stones here described will be found in Class 27, devoted to Mineral Manufactures.

Peat and its Products. (Exhibitors 222, 225, 227, 228.)—The "turf" of Ireland and other places, formed by the growth and decomposition of the *sphagnum*, has from time to time attracted much attention. In the locality of the bogs it is largely employed for fuel, and attempts have been made by various methods of condensation to render it generally available for that purpose. Compression has been employed for effecting its consolidation, and thus by reducing its bulk to such limits as would admit of easy stowage. One exhibitor (228) condenses peat by the following process:—The turf as dug is thrown into a large hopper, at the base of which are strong-toothed iron rollers; by a large supply of water the peat is carried through these rollers, and then passed into a cylindrical sieve which separates the fibrous from the more finely-divided matter. This last is received in tanks, and after allowing sufficient time for the deposit of the fine peaty matter, the water is run off and the mass allowed to dry. In this way the spongy nature of the peat is broken up, and a firmly-coherent mass is produced, of which specimens are exhibited. The other peat products are of the highest interest. By destructive distillation, acetic acid, ammonia, naphtha, or pyroxilic spirit, chloroform, and paraffine, with

tar and other matters, are obtained. The discussion on the question of the production of these will now be settled by the publication of the Report of Sir Robert Kane to the Commissioner of Woods and Works, in which he proves the existence of all these chemical compounds, and furnishes data by which the economic question may be determined.

The Bituminous Shales (221) have been recently worked for the hydro-carbon compounds they contain. On the Rhine a manufactory of some extent has been formed for the purpose of obtaining this material.

The raw material, the commercial name of which is "Bituminous shale," sometimes called "Kimmeridge coal," or "clay," is obtained from the cliffs at Kimmeridge, in the Isle of Purbeck, in the county of Dorset, and was begun to be quarried in August, 1849.

It is a composition of animal and vegetable remains, intimately united by a cement, having for its base silicate of alumina, and is used for the purpose of obtaining by distillation volatile mineral naphtha,—a fatty oil, useful as a lubricant for machinery: asphaltum, the residuum from the retorts, is afterwards manufactured, by the addition of ammonia, and other fertilizers, into an artificial manure. The production from the above material is entirely new in the commercial world, and was in England commenced in November, 1849, by the present Company.

The volatile mineral naphtha is light and transparent, adapted for lamps, as a solvent for India-rubber, gutta percha, &c., and many other purposes in the arts and manufactures (to which naphtha or camphine is applicable).

The products from the destructive distillation of coal (223) may be studied with advantage in connection with those obtained from peat and shale.

Coal and Coke. (Exhibitors 219 to 275 generally.)—An account of the distribution of coal will be found in the Descriptive and Illustrated Catalogue, in which is also embraced some description of the peculiar characteristics of

the several varieties; to that paper the reader is referred for such information as could not be condensed into the limits of this Handbook.

The kinds of coal exhibited are—

1. *Cannel Coal*, containing, as it does, a large percentage of volatile matter, is very inflammable. It may—like *jet*, which is a variety of coal—be worked into various ornamental articles, of which many are exhibited.

2. *Bituminous Coal*, the ordinary coal which we employ in our domestic fires. Of this coal great varieties exist, depending on the conditions under which the deposits took place. They vary greatly in the quantity of carbon and bituminous matters which they contain. The best account of the differences will be found in the Report on the Coal employed for the Steam Navy, by Sir H. De la Beche and Dr. Lyon Playfair. In the collection exhibited we have the very beautiful iridescent coal known as the Peacock Coal. This colouring arises from excessively thin films of sulphur, which refract light after the manner of a soap-bubble, or a slight layer of oil upon water. Another kind shows a very peculiar structure, which might almost be called crystalline. It is difficult to account for this peculiar arrangement of particles, which can neither be referred to the woody structure of the plant from which the coal was formed nor to any process of crystallization; it is evidently the result of an arrangement of particles under some peculiarities of mechanical force, the result depending upon the form of the ultimate particles.

Anthracite Coal.—When the mass of vegetable matter passing into coal has been exposed to a very high temperature, as by the direct contact of volcanic rocks, it becomes almost completely carbonized, and the variety of coal called anthracite (from *ἄνθραξ, coal*). In the South Wales coal-fields we have the remarkable example of beds of bituminous coal gradually losing their volatile constituents, and becoming more and more anthracitic, until, at the western extremity of the coal-field, this kind of coal

alone prevails. Anthracite has been formed artificially by the long-continued action of a temperature insufficient for coking.

Several very fine masses of *coke* are exhibited. This is obtained by driving off the volatile matter, carbon in a state of tolerable purity being left behind. The process of coking is effected in peculiarly-constructed ovens, by which the quantity of air admitted can be regulated. When coke is well made from good coal it is of sufficient hardness to cut glass; therefore, in coking coal, we advance one step towards the formation of diamond. At least 34 millions of tons of coal are annually raised in the British isles, the value of which, at the pit's mouth, is above 9,000,000*l.*

Compressed and Artificial Fuel. (Exhibitors, 230, 232, 242, 252.)—The artificial fuels have one general character; they are carbonaceous matter; generally, small coal cemented together by some bituminous matters.

The manufactory, under Warlich's patent, is as follows:—Small coal, of the very best descriptions, is amalgamated with bituminous matter obtained from coal, in which state it is placed in moulds and submitted to an immense pressure by hydraulic machinery. It is subsequently carbonised in retorts, at an intense heat, until all smell of the bituminous matter used has been got rid of, and the vegetable matter and noxious gases existing in the coal, drawn off; after which it is fit for shipment.

The Report on the Coals for the Steam Navy contains some important information on artificial fuel.

Iron Ores and Iron Manufacture. (Exhibitors 400 to 428 generally, 447, 448, 449.)—In the collection of iron ores collected by Mr. S. Blackwell, of Dudley, we have an exemplification of all the varieties employed in this country. The gross annual production of iron in this country is now upwards of 2,250,000 tons: South Wales furnishes 700,000 tons, South Staffordshire (including Worcestershire), 600,000 tons, and Scotland 600,000 tons. To the

Descriptive and Illustrated Catalogue, Mr. Blackwell furnished an account of all the beds of iron from which he has exhibited specimens, including also an account of the number of iron furnaces in and out of blast. From that paper we take the following, which is an excellent condensed account of our iron-producing districts :—

"So extensive are the ironstone beds of the coal measures, that they furnish in themselves the greater part of the iron produced in Great Britain; but the iron-making resources of the kingdom are by no means confined to them. The carboniferous or mountain limestones of Lancashire, Cumberland, Durham, the Forest of Dean, Derbyshire, Somersetshire, and South Wales, all furnish important beds and veins of hæmatite. Those of Ulverston, Whitehaven, and the Forest of Dean, are the most extensively worked, and seem to be almost exhaustless. The brown hæmatites and white carbonates of Alston Moor and Weardale also exist in such large masses that they must ultimately become of great importance. In the older rocks of Devon and Cornwall are found many important veins of black hæmatite, and in the granite of Dartmoor numerous veins of magnetic oxide and specular iron ore. The new red sandstone furnishes in its lowest measures beds of hæmatite conglomerate. In the lias and oolites are important beds of argillaceous ironstone, now becoming extensively worked; and the iron ores of the greensand of Sussex, once the seat of a considerable manufacture of iron, will, in all probability, again soon become available, by means of the facility of railway communications. The produce of the manufacture of iron in Great Britain in 1750 was only about 30,000 tons; in 1800 it had increased to 180,000 tons; in 1825 to 600,000 tons; in the following year the duties upon the introduction of foreign iron were either removed or rendered nominal, since which the production of iron has nearly quadrupled itself, being now about 2,250,000 tons."

The increased use of iron in this country during the

present century has been truly extraordinary. The importations of this metal at the beginning of this century amounted to about 40,000 tons yearly, and the quantity made at home was under 150,000 tons. It was given in evidence by Sir John Guest, before the Committee of 1840 on Import Duties, that in the year 1806 the quantity of iron made in the kingdom was increased to 258,000 tons; that in 1823 the quantity produced was 452,000 tons; in 1825 it had reached 581,000 tons; and in 1828 the quantity was 703,000 tons.

A fresh impulse has since been given to this branch of manufacture through the great actual extension of railways. There has not been any recent official statement put forth showing the progress made in England, but a careful account of the make of iron in Scotland was drawn up in July, 1845, when it appeared that there were 76 furnaces in blast, producing 8,250 tons of iron weekly, or at the rate of 412,500 tons in the year of 50 weeks. There were besides, at that time, 10 other furnaces being built, and it is probable that at this time the quantity of iron made in Scotland is not short of 600,000 tons in the year: this is principally obtained from the black-band ironstone, the use of which is due to the suggestions of Mr Mushet, whose work on "Iron and Steel," together with that of Overman, and Mr. Porter's "Progress of the Nation," who has entered fully into the statistics of the iron manufacture, may be consulted with advantage.

The Monkland Iron Works (426) are of great importance.

These works are situated on the river Calder, a tributary of the Clyde, about 10 miles eastward of Glasgow, in the county of Lanark: they were commenced in 1805, and were first employed in the manufacture of iron from scrap-iron by forges and rolling-mills driven by water, and also in the manufacture of steel, files, &c.—the tilt-hammer, rolling and slitting mills, being driven by water. In 1825, the smelting of iron was commenced, there being an abundant supply of coal, ironstone, and limestone in this

district; and the works consist of nine blast-furnaces, producing about 60,000 tons of pig-iron annually; six refineries and forges, and rolling and slitting mills, to convert all the pig-iron into the malleable state. The produce of malleable iron is about 40,000 tons annually, consisting of rails, bar-iron of all sizes, boiler-plates, nail-rods, sheet-iron, angle-iron, &c.; and there are employed at the mines, situated around the works and in the works, about 2,500 workmen. There are six schools for the education of the workmen and their families, and the number attending school at present is about 1,400.

The iron manufacture in Scotland has increased very much of late years. In 1827 there were only 18 furnaces in blast, and an annual produce of 36,000 tons; and at present there are above 100 in blast, producing upwards of 600,000 tons annually.

This iron is produced chiefly from the black-band ironstone, which contains a large proportion of coaly matter, and is turned out from the pits into large heaps, about 15 feet in thickness, and containing several thousand tons: these are set fire to, and there is a sufficient quantity of inflammable matter in the ironstone to roast it into a fit state for the blast-furnace, without any manipulation.

The Model of Ebbw Vale (412), and of the iron furnaces employed at the Ebbw Valley Works, from which we may derive a very complete idea of the mode of occurrence of the ironstone bands in the coal measures, and of the method adopted for smelting iron by the hot and cold blast, should be attentively examined. In the furnaces are shown the arrangements for collecting the gases from the top of the furnace, of conveying them under the boilers of the steam-engines, &c., and of thus economising a great deal of heat, formerly entirely wasted.

At the Blaina Ironworks a similar method is adopted, and a model explains the arrangement (413). The novelty of which is, completely closing the furnace-top for collecting the gases, which are drawn off, by means of a branch tube

for generating steam, heating air, &c., and introducing a fixed cone in the centre for the equal distribution of the material. Thus, by simply raising the changing-ring, the materials fall to the wall of the furnace, which gives them a concave surface in lieu of a convex one. The largest particles of fuel now roll to the centre of the furnace, which concentrates the heat to that part where it is most required, namely, the centre of the furnace.

Solly's Iron (410).—Among the various improvements which have been made in mineral products during the last few years, none, perhaps, are more striking than the refining of British iron by chemical processes, such as employing manganese and salt, &c., by which it is rendered suitable for conversion into steel. Some fifteen years since, we believe that the only English irons which could be employed for that purpose were manufactured by the Low Moor Iron Company, near Bradford, in Yorkshire, who are large exhibitors in Class 22. At the present time there are, in addition, the Bowling, the Milton, the Farnley Iron Companies in Yorkshire, and several works in South Staffordshire. Messrs. Solly, of Leabrook, are conspicuous in this class by the case which they exhibit of their iron and steel, and of a great variety of tools and cutlery made therefrom by the above process. These are purposes for which Swedish and Russian iron had previously been considered indispensable.

Tin-plates and Galvanised Tinned-iron. (Exhibitors 411, 417, 436, 500.)—The ordinary process of tinning iron, although comparatively a simple operation, requires much careful manipulation. In the first place, metal of a peculiar quality must be selected: this is rolled into sheets of the required thinness by being passed when heated between highly-polished rollers; the operation of heating even demanding great attention, as on the quality of the fuel and the degree of heat depends the colour of the finished sheet. Sheets prepared with coal as a fuel are ordinarily black from the presence of a small quantity of sulphur;

whereas those prepared with charcoal are of a fine blue colour on the surface. Some books of iron exhibited well display these peculiarities. Charcoal-iron (417), as it is labelled, is always preferred for the manufacture of tin-plates. The plates when cut of the required size are thoroughly cleaned by the action of sulphuric acid, so that all oxidation may be removed, and then plunged into melted tin. Such are the essential parts of the process, many of its details being omitted.

Iron covered with zinc has been called galvanised iron, from the fact that we have two metals in different electrical conditions; the zinc, suffering chemical change, oxidising, and acting as a protecting agent to the iron. *Galvanised tinned-iron* (436) is prepared in the following manner. A quantity of chloride of tin is made by dissolving granulated tin in muriatic acid; this is largely diluted with water, and poured into a tank arranged in this way: several small pieces of zinc are strewed over the bottom, and on this are placed some sheets of iron; then more zinc is sprinkled on this, and another layer of sheets of iron placed on these until the cistern is full. Electro-chemical action appears to be set up, and the iron is shortly covered with a film of tin. After this the sheets are zinced, by being passed through a shallow bath of melted zinc, and then through rollers. Steam power is employed in this process, by which any degree of speed can be obtained, and thus only such a coating of zinc allowed to fix itself on the iron as may be deemed necessary, and uniformity secured on any quantity. Sheets are manufactured in this way of very large size, the one in the West Main Avenue being 11 feet by 3 feet; and they are curved or corrugated, or stamped into plates and tiles for roofing purposes. The patentees of this process have also shown that this galvanized tinned-iron can be covered with a coating of lead, and in this way be employed where zinc would be objectionable, and the iron may be used very much thinner than it would be prudent to employ

lead; hence the patentee's claim for it—the advantage of lightness, in addition to the ordinary qualities of lead. Another material exhibited, called by the patentees plumbic zinc, is zinc coated on one or both sides with lead; the principal advantages of this appearing to be the combination of the lightness of the sheet of zinc with the slow oxidisability of the lead as compared with that metal.

Alloys of Iron. (428.)—In this case are some interesting combinations of iron with the other metals; and of wrought and cast iron, with some manufactured articles therefrom. Mr. Stirling has recently made a communication on these alloys to the Royal Institution of Edinburgh, in which he has fully entered into the question of alloying iron. In the Report of the Commissioners on the Iron employed in Railway Structures, will be found a statement of some experiments on the combined wrought and cast iron of Mr. Morries Stirling.

Models of Coal Mines, &c. (Exhibitors 253, 403, 404, 413, 431, 432.)—In these are illustrated the different methods of working and ventilating coal mines. In the Newcastle-on-Tyne district they work the "whole coal" in each district of the mine before commencing to take away the pillars: they then commence to remove the pillars of coal at the remotest extremity. By an improved process of working introduced, the pillars are taken away in the same operation as working the "whole mine," at such a distance as will admit of a double-safety current of air passing between the whole-working and the pillar-working, so that the former may be lighted with candles and the latter by safety-lamps. The long-wall system, is removing the coal in one entire breadth or breast, no pillars being left. The main roads in the mine being secured by building stone pillars; in other cases pillars of coal are left to secure the permanency of the main way. It is, of course, understood, that as coal is worked on the bed, the superincumbent mass would fall if it was not supported; hence the necessity of pillars.

Safety Lamps are associated with these models. Previously to the introduction of these, the steel-mill was employed in dangerous places—the stream of sparks produced by the attrition of the steel against a piece of flint giving some light. The fire-damp of the coal-mines is a carburetted hydrogen, which, when mixed with a portion of atmospheric air, forms an explosive compound; a temperature above that of ordinary incandescence is, however, necessary to occasion its ignition. By the investigations of Sir Humphry Davy it was proved that flame would not, under ordinary circumstances, pass through the meshes of fine wire gauze. This may be proved by holding a piece of wire gauze over the flame of a candle—the smoke will freely ascend, but the flame will be restrained. By completely surrounding a lamp, therefore, with wire gauze, the desired end is effected of securing the flame from the mass of explosive mixture. The carburetted hydrogen passes into the flame through the cage easily enough, but being exploded the flame cannot pass out: therefore, in a dangerous atmosphere a series of small explosions are constantly occurring within the cage, while the risk of firing the atmosphere around is very small. Accidents do occur where the "Davy," as the lamp is called, is used, but these are ordinarily the result of incaution. Perfect ventilation is, however, the most effective security to the miner.

Ventilation of Coal Mines. (Exhibitors 403, 404.)—The mode of arranging the "air-ways," so that the column of air drawn by the furnace in the "up-cast" shaft brings the whole mass along given lines, while the current of pure air is supplied through the "down-cast" shaft, is shown in the models (413, 432). In those by Mr. Brunton and Mr. Cawley, mechanical arrangements are employed to produce a strong current of air. A screw in one case, and a chambered wheel in the other, being set in rapid motion, discharges the air from one shaft, the supply naturally descending the other to supply the mine.

In effecting this system of currents, it is essential that the "ways" are properly adjusted, so that a stream of air constantly flows along the proper passages, sweeping, as it were, the whole of the mine. Doors are placed at certain points, at which are stationed boys, whose duty it is to close them immediately any coals or waggons have passed through them. No. 418 is a *model for opening and closing doors by a reversion of levers*, by which the service of the boy is dispensed with, and the certain closing of the doors secured by the waggon itself, as it passes onward, striking against a lever connected with the door.

Model Machinery and Apparatus for dressing the inferior Copper Ores, called "Halvans," at the Tywarnhaile Mines. (434.)—The poorer ores produced at this mine, the property of H.R.H. the Prince of Wales, which would not pay for working by the ordinary processes, are, by the machinery introduced, worked very profitably. They are, being reduced to a small size, first subjected to the action of the crushing machine; they then pass through the cylindrical sieve, and are washed and passed through the series of channels to the round buddle, in which the metallic particles are separated from the others, the earthy matters being removed by the slowly-flowing water. By inspection of the model, made to the scale of two inches to the foot, the process will be easily understood, which could not be rendered intelligible by any description without diagrams. Samples of the ores in different stages of preparation accompany this model in illustration.

Tools employed in Mining and Quarrying. (Exhibitors 430, 451, 461.)—The picks, borers, &c., employed at the Abercarne collieries, and used for raising the coal and stone exhibited with them, merit inspection. The forms of the picks are carefully studied, and it is stated that great advantage has resulted from the use of cast-steel borers, for working in hard rock, in the place of iron ones with steel ends. In the manufacture of these tools it is found

to be of much importance to secure certain relations between the size of the bits and stocks, which is another point particularly claimed as novel. In prosecuting the works at these collieries, galvanism has been brought most efficiently into operation for the purpose of blasting. The process consists in carrying wires down into the hole in the rock, uniting these with a piece of thin platinum, and charging with gunpowder as usual; connection is then made with the battery, and any number of holes are fired at the same time. By this means the rending power is greatly increased; and it is stated, that in three months work can be done, which by the ordinary method of blasting would occupy twelve. Some other adjustments—particularly the use of gutta percha for the Hogar-pipe, by which water is drawn from the bottom of the shaft, or "sump"—are worthy of the attention of every miner. These are explained by drawings on the wall, behind the tools. The tools employed in the Cornish mines hang on the neighbouring wall.

The Pick for dressing Granite (461), by which a series of steel points sharpened can be from time to time adjusted, appears to have been used in the granite quarries of Cornwall with much advantage.

Tin Ores—Manufactured Tin—Model. (Exhibitors 440, 455, 457, 468, 469, 470, 485.)—Tin appears to have been raised in Cornwall from the earliest historic times; and there are, scattered over the county, to be found numerous relics of old workings which are usually—and probably with much correctness—attributed to the Romans. In some places remains of rude furnaces and collections of slags are found; the former are called "Jews' works," and the latter "Jews' attal," with one curious exception, where some large heaps of refuse are still known by the name of "*Attal Saracen.*" Often rude blocks of tin are found, which are called "*Jews' tin,*" and of one of these there is a good example in the collection from the Truro Committee. It is not improbable that these rude blocks were of the

kind supplied to the Phœnicians, who traded to the Cassiterides, or Tin Islands, for that metal. Tin does not occur in any great variety of forms: those which are commercially valuable are only displayed; and by a close examination of the specimens before us, we shall be enabled to trace out the whole of these varieties. The ores of tin are obtained from two different sources—stream-works and mines. In the stream-works, the oxide of tin, or black tin of the miner, is found nearly pure, from the size of small grains of sand and rounded pebbles, up to that of large water-worn boulders, mixed with the detrital deposits of running streams or of dried-up rivers. These detrital deposits consist principally or entirely of decomposed granite, from the washing of which china-clay is obtainable. In Carclaze tin mine, or rather quarry, the black tin found *in situ*, in a very friable decomposing rock, is obtained by imitating the operations of nature, the rock being broken down by directing streams of water through artificial channels. The stream-works in Devon and Cornwall have been in former times the principal source from which this ore was obtained, but they appear to be nearly exhausted. Streaming for tin is still carried on upon St. Austle moors, at the Pentuan Valley, and in many other parts, the principal supply, however, being now derived from mine-workings.

It should be explained that stream-works consist merely of digging over and properly washing the debris of the primary rocks, which has been during ages separated by the disintegrating action of atmospheric changes, and by floods carried into and deposited in the valleys.

In these deposits the tin is usually found at the bottom, as being heavier than the matters forming the superincumbent mass. That these deposits are of comparatively recent origin is proved from the occurrence of human skulls and the works of man amid the detrital accumulations. At Carnon stream the remains of man, of deer, and other animals, with wood, moss, leaves, and nuts, have

been found 53 feet beneath the surface of mud and sand, and at Pentuan human skulls, mixed with the remains of deer, oxen, hogs, and whales, have been discovered under 40 feet of detrital accumulation. The operation of *streaming*, as it is called, bears a close analogy to that of gold-washing, and consists essentially in washing away all the valueless matter, leaving the heavier stanniferous pebbles and sand behind.

The ordinary process of smelting tin is a very simple one, consisting of little more than mixing the ore with some carbonaceous matter which may rob it of its oxygen, exposing the whole to sufficient heat in a reverberatory furnace, until the pure metal is obtained, and then running it into moulds, similar to the one in the Truro collection.

Grain tin is a very pure metal, the semi-crystalline structure being produced by artificial means. It often occurs that the ores contain impurities which very materially diminish the value of the tin by combining with the metal, and rendering it unfit for the purposes to which it is ordinarily applied.

Separation of Wolfram from Tin. (485.)—Wolfram (*Tungstate of Iron*) is the most difficult to treat, and it is only recently that any process of treating tin containing wolfram has been thoroughly successful. The small case exhibited well illustrates this process.

The series of specimens have been obtained from Drake Walls Mine, on the banks of the Tamar. In this mine is a curious illustration of the ancient method of mining, combined with the modern plan of proceeding. From want of machinery the operations of the ancient miner were of a very restricted character, consisting rather of a series of quarrying than of mining operations. Hence we find in the mine a deep "gunnis" or pit worked out, to the extent of some 30 fathoms in depth, 150 to 200 fathoms in length, and only 20 feet wide. Modern workings have been undertaken some distance below the bottom of this

pit, a solid arch of ground being left of considerable thickness to prevent risk of injury to the lower workings from the falling together of the sides of this immense chasm. The ore is brought to surface, or "grass," in an iron waggon, running between four rails, adjusted to the irregular inclinations of the sides of the chasm, by the power of a steam-engine and water-wheel. The ore is discharged into another waggon on a horizontal railway, and conveyed to the dressing-floor, where the large masses are broken down or "spalled" to a size suitable for the crusher. The whole is then washed, to remove the mud, and after being picked over by "bal maidens" (girls employed at the mine to remove useless waste), the residue is conveyed to the powerful crusher, and is ground down to a coarse powder. In this mine the black tin is sufficiently coarse-grained to allow of the effectual separation of the waste by this simple process; but in the greater number of mines the black tin is of such fine grain, and so completely distributed throughout the entire mass of the matrix, that it is impossible to dress it properly without reducing it to a very fine powder, which can only be effected by stamping.

From the crusher the ore is taken to the dressing-floors, where, by a series of washings in running streams and in still water, the whole of the earthy matters are almost completely separated. The residue consists of the black tin, associated with iron, copper, and arsenical pyrites, and with wolfram.

By the action of the water, this mixture of metallic matters, termed *witts*, will have been sorted out into different-sized grains, technically called "jigged witts," "flucan witts," smalls, slimes, &c. These witts are, in the next place, conveyed to the burning-house, where they are roasted in a large reverberatory furnace, at a red heat. The black tin and wolfram remain unaffected thereby, but the sulphur of the pyrites is converted into sulphurous acid gas, which passes away into the atmosphere, and

partly into sulphuric acid, which combines with any copper present. At the same time the iron is oxidised, and rendered lighter than before, and the arsenic is converted into arsenious acid, which, being volatilised by the heat, passes on into the flues and is there condensed.

The calcined ore is again washed on the burning-house floors; and the clean black tin obtained, if free from wolfram, would be ready for the smelter, and would vary in value according to the current price of the metal, from *50l.* to *65l.* per ton. The presence of wolfram very much affects the price of the ore. Thus, a sample which obtained only *42l.* per ton, was, after having been subjected to the process for the separation of the wolfram, worth *56l.* 10*s*.

In consequence of the specific gravity of wolfram being greater than that of black tin, it could not be separated by any washing operation.

Such an ore is now mixed, in proportions indicated by the quantity of wolfram present, with soda-ash, a crude carbonate of soda, or salt-cake, sulphate of soda, and the mixture calcined in a reverberatory furnace provided with an iron bed to prevent the reactions that would otherwise take place between the constituents of the bricks, the soda, the tin, and the tungsten. By this calcination at a red heat, the tungstic acid is obliged to leave the iron and to combine with the soda, producing tungstate of soda, which is soluble in water, and is thus capable of being easily removed. The residuary oxides of iron and manganese are then separated by washing, and the black tin obtained pure.

By evaporating, and thereby concentrating the solution of tungstate of soda, it is obtained in the crystalline form, and is now being used as a mordant for dyeing purposes, and for the preparation of pigments. Thus eventually the wolfram, instead of being the cause of deteriorating the value of the tin ore, may be the means of enhancing it.

The produce of tin ore in Cornwall and Devon for the last seven years has been as follows:—

Years.	Tons.
1844	7,507
1845	7,739
1846	8,945
1847	10,072
1848	10,176
1849	10,719
1850	10,052

In 1849,	299 tons of tin were		imported.
,,	2,214	,,	exported.
1850,	1,798	,,	imported.
,,	2,211	,,	exported.

Copper Ore—Smelting and processes of Reduction. (Exhibitors 439, 441 to 446, 450, 452, 453, 454, 473, 475, 516, 517, 518.)—The ordinary copper ore of this country is the yellow sulphuret: this is a double sulphuret of copper and iron. Sometimes a pure sulphuret of copper or grey ore is raised. Other ores of copper may be regarded rather as mineralogical specimens than as practical illustrations of the useful ore. Several varieties of these copper ores are exhibited. The native copper, from the serpentine formations of the Lizard, may be regarded as among the most curious of our mineral formations. It is found spreading itself out through the cracks in the rocks in a very remarkable manner. Opinion is divided as to whether these formations are the result of sublimation or of deposition from water. At the bottom of the North-west Stairs will be found two remarkable examples of this copper formation from Trenance Mines. On the eastern table of this class three specimens are also associated: these are respectively from the Lizard, in Cornwall, from the trap-rocks of the Boyleston Quarry, Renfrewshire, and from Lake Superior, in America. These have been placed together for the purpose of showing the peculiar conditions under which these formations occur. In one of the larger specimens from the Carradon Mines will be found a great quantity of native copper, and also of the red oxide;

and in those masses of ore adjoining, and on the table, the other commercial varieties may be studied.

The Swansea Committee (473) exhibit illustrations of the ordinary processes of copper smelting, showing the gradual separation of the sulphur, and the increasing purity of the metal at each stage of the process.

At Swansea, nearly all the copper smelting of Great Britain is carried on. It being found more economical to take the copper ore to the coal, than the coal to the ore.

Messrs. Bankart exhibit illustrations of their patent process of reducing copper (429); which consists in roasting the sulphurets of copper at a moderate heat, and with regulated accession of atmospheric air, by which the sulphur becomes converted into sulphuric acid, and combining with a portion of the copper, forms a soluble sulphate of that metal. This is dissolved, and iron is thrown into the solution, by which copper is precipitated, the iron taking its place as a sulphate, which is afterwards crystallized out. In this way much of the copper of the ore, which is the double sulphuret of copper and iron from the Cobre mines in Cuba, is obtained; but still a portion remains, which requires treating in the following manner.

In *this state* no additional roasting would have any other effect than to further oxidise portions of metal which had not received their full dose of oxygen. By mixing with this roasted ore a portion of the same ore in its *raw state*, the sulphur of the latter, which would otherwise have gone off in the form of sulphurous acid gas merely, receives *through the agency of the peroxide of iron* present, an additional dose of oxygen, forming sulphuric acid; this again acts on a considerable portion of the oxide of copper, uniting with it and forming sulphate of copper, to be again extracted by boiling water as before, and so on till the whole of the copper is obtained. And by using in the *last* operation a sulphur ore which contains *little or no copper*, the residuum is found to consist almost exclusively of *silica and peroxide of iron.*

Longmaid's patent consists in roasting the ores with salt (chloride of sodium): the formation of sulphate of soda is the consequence of the combination of sulphuric acid with the soda of the salt, and the production of muriates by the action of the chlorine on the metals present (441). Some portions of this process have been ong in action for the manufacture of soda-ash: for the separation of silver from copper ore it appears to offer some advantages. Lowe's process, also a patent one, is exhibited (489).

The remarkable increase of the production of copper in this country is deserving of notice. In 1744, 7,000 tons of copper ore were raised; in the United Kingdom, in 1844, 150,000 tons. The value of the copper produced in 1770 was 170,000*l.*, that raised in 1844 was 820,000*l.*, and in 1847 it amounted to 889,287*l.* in Cornwall alone.

At Swansea, in addition to the copper ore sold at the Cornish "ticketings," as the sales are called, from the circumstance that the prices offered are given in on tickets, there was, in 1847, sold from the—

	Tons.
Welsh mines	340
Irish mines	14,373
English mines	406
Foreign mines	50,819
	65,938

The value of this mineral is therefore now considerable; and yet, fifty years since, tin mines were abandoned when they came to the "yellows," as the copper pyrites were called, as being thought of insufficient value to pay the working.

Zinc Ores and Manufactured Zinc. (Exhibitors 437, 492, 503, 506.)—The ores of zinc exhibited are the sulphuret (called also "blende," from the German, signifying *glistening*), the carbonate of zinc or calamine, from the Latin *calamus*, a reed, as, when in fusion, it adheres to the base of the furnace in the form of reeds. The sulphurets of

zinc—the *black jack* of English miners—are from Cornwall, the Isle of Man, and from Cumberland. It is found in many other parts associated with lead and copper. Its chemical composition is—

Zinc	61·5
Sulphur	33
Iron	4

The calamine is from the Alston-moor mines, and, by analysis, it is found to consist of—

Oxide of zinc	64·8
Carbonic acid	35·2

Specimens of this ore from the Vieille Montagne mines are associated with the manufactures of this Company. The calamine from Altenberg, the former name of these mines (the "Old Mountain"), has been worked since 1435; but for four centuries it was employed merely as an earth to make brass, as it was not known to contain any metal. A succinct account of the discovery of zinc is instructive.

The reduction of this metal is of comparatively modern date. Calamine was employed by the ancients in the manufacture of brass, but it was not known that a combination of the copper with another metal took place in the process. Bergman, writing on the subject, says, "The semi-metal which at present is called zinc, was not known so much as by name to the ancient Greeks and Arabians. The name which it bears at present first occurs in Theophrastus Paracelsus; but no one as yet has been able to discover the origin of this appellation. Agricola calls it *contrefeyn*; Boyle, *speltrina*; by others it is denominated *sprauter* and Indian tin. Albertus Magnus, more properly called Bolstadt, who died in 1280—the first who makes express mention of this semi-metal—asserts that it approaches to a metallic nature, and relates that it is inflammable." The celebrated Brandt, in 1735, showed that blende contained zinc; and soon after Van Swab actually extracted it from the Bolognian pseudo-galena, which possesses a metallic splendour. The Baron Trenck, in 1744, determined the presence of zinc in pseudo-galena, from the

flame and the flowers; and in 1746 Mr. Marygras set the matter beyond all doubt. The late Dr. J. Lawson, observing that the flowers, the sublimed oxide of *lapis calimanaris*, were the same as those of zinc, and that its effects on copper were also the same as that metal, never remitted his endeavours till he found the method of separating pure zinc from that ore. Mr. Champion, of Bristol, being taught by Dr. Lawson, established works for separating the metal from both blende and calamine, and rendered zinc or spelter merchantable in England; and learned and practised the art of making ingot brass for melting, and plate brass for sheets and wire drawing: to him succeeded Philip George, jun., of Bristol. Public Companies were established for making brass, &c.:—Harford and Bristol Brass and Copper Company; Freeman's brass and Copper Company. Messrs. Hobson and Co., of Sheffield, discovered the malleability of spelter, and applied to the only maker, Philip George, jun., of Bristol, to work it out, about 40 years since.

The processes of reducing zinc are peculiar, from the circumstance that when melted, in contact with atmospheric air, it enters into combustion. Oxide of zinc is rapidly formed, which passes off in a very fine state, ordinarily known as "philosopher's wool." The Vieille Montagne Company, who exhibit in this and in the Foreign departments the productions from their mines, raise very large quantities of calamine, which they reduce by the English method of condensation. The process is, to draw off the melted zinc from the bottom of closed crucibles, after the ore, mixed with coal, has been exposed to the action of heat for some time, and allow it to flow into water. Eight tons of calamine and 22 tons of coal yield about two tons of zinc.

The mines from which the manufactured specimens are exhibited are situated upon part of the Belgian, Prussian, and neutral territories, between the towns of Aix-la-Chapelle and Verviers. The Abbe Deny, in 1805, first esta-

blished the smelting works which passed into the hands of the Mosselman family in 1813, and in 1837 into possession of the Company, producing now about 12,000 tons of zinc annually. The uses to which this metal is applied—sheets of various sizes, perforated sheets, mouldings and castings in zinc—are fully illustrated. The sheets of zinc are imported from the Company's works—perforated in this country, and re-exported: this branch of manufacture not being carried on to any extent on the Continent. Ornamental zinc-casting, in connection with this Company, is about to be established in this country.

Our imports and exports of this metal for the last three years have been as follows:—

	Imports.	Exports.
	Tons.	Tons.
1848	12,769	4,232
1849	13,525	4,339
1850	15,914	5,397

Lead Ores. (Exhibitors 483, 484, 491 to 497, 508, 509, 510, 523.)—The value of our lead-producing districts represented in the Exhibition may be judged of by the following table of the produce of lead for five years:—

	1845	1846	1847	1848	1849
	Tons.	Tons.	Tons.	Tons.	Tons.
Devon and Cornwall	7,188	5,947	8,333	7,458	8,045
Northern Counties	28,820	27,621	28,387	28,893	30,781
Ireland	855	811	1,380	1,188	1,653
Scotland	901	942	822	1,736	957
South Wales. . .	4,807	5,084	6,419	4,053	5,941
North Wales. . .	6,207	4,943	5,875	7,069	7,448
Shropshire . . .	2,500	3,200	3,000	2,800	2,310

In the important district of northern England the chief mines are those of W. B. Beaumont, Esq., in East and West Allandale and Weardale; the London Lead Company in Durham, Cumberland, and Westmoreland; the Commissioners of Greenwich Hospital; and the Derwent

Mining Company—all occupying portions of a great mountainous district, of which Cross-fell and Kilhope-law form the most conspicuous elevation, one at 2,901, the other at 2,200 feet, above the sea. In Cornwall, the principal lead-mine is East Huel Rose, near Truro; and in Devonshire, the Tamar silver-lead mine and the mines at Beeralston. In Wales, the Cardiganshire and Flintshire mines are the most productive. Those of Cardiganshire have been worked for many centuries. The New River was brought into London by Sir Hugh Myddelton from the profits which he obtained from the Cardiganshire mines.

The chief districts in Scotland are in Argyllshire and Kirkcudbrightshire; and in Ireland, county Wicklow. Lead is also raised largely in the Isle of Man; the mines producing in 1849, 2,826 tons of ore, containing 1,535 tons of lead.

The ores of lead commercially valuable are the sulphuret and carbonate, the former existing in by far the largest quantities. Most of the lead ores contain silver: this is now separated by Mr. Pattinson's process, by which the three large masses of silver exhibited were extracted.

The illustrations of lead mining contributed by Mr. Beaumont's mines, will be examined with interest, as showing the processes of dressing the ores of lead for the market, and the progress of conversion into pig lead. A case contributed by the working men contains a complete series of the metallic, and some of the earthy, minerals from the mines in which they are employed.

In connection with these are the desilverising processes of Mr. Pattinson. This is so important, that it is thought desirable to describe it fully.

This process, discovered by Mr. Pattinson, in 1829, is founded upon the peculiar physical fact, that when lead containing silver is melted in a crucible or other suitable vessel, and suffered to cool very slowly with constant stirring,—at a certain temperature near the melting point of lead, small solid particles or crystals of lead begin to

form within the fluid metal, which, as they are formed, sink to the bottom of the vessel, and on being removed, are found to contain much less silver than the original lead,—the still fluid lead from which the crystals are taken, being rendered proportionally richer in silver.

The application of this discovery to practice constitutes "Pattinson's Process," which, after the principle detailed above is understood, is sufficiently simple. Eight or ten cast-iron melting-pots are placed in a row, with a fire underneath each pot, which is capable of holding about five tons of lead. On commencing the process, five tons of lead, which may be called original lead, and may contain about ten ounces of silver per ton of lead, are introduced into one of the pots about the middle of the series: this being melted, it is carefully skimmed and the fire withdrawn from underneath the pot; the lead then cools very slowly, and is constantly stirred. In a short time small solid particles of crystals of lead begin to form among the fluid lead, and as they accumulate and sink to the bottom of the pot, are removed by means of a perforated iron ladle similar to the one exhibited, and carried over into the next pot to the left in the series. This operation goes on until about four tons of crystals are taken out of the pot, and placed in the pot No. 5, at which time the lead of the pot No. 4 will contain about thirty ounces of silver per ton, and the lead of the pot No. 5, about five ounces of silver per ton. The enriched lead from pot No. 4 is then ladled into the next pot to the right in the series (No. 3), and the same operation repeated in the pot No. 4, on a fresh portion of original lead. In this way original lead is continually introduced, and the poor lead from it passes to the left, the rich lead passing to the right; and as each pot in the series, when filled with lead of its quality as regards content of silver, is continually crystallized, the poor lead passing to the left and the rich lead to the right in every case, it is obvious, that the crystallized lead from the pots on the

left must become poorer and poorer, while the enriched lead, as it advances successively from pot to pot to the right, becomes richer and richer, the actual result being, that in the end, the crystallized poor lead contains but a mere trace of silver, while the liquid lead, on the other hand, becomes so rich, that a large plate of silver is obtained by submitting but a small quantity of this rich lead to cupellation. By these repeated crystallizations, the poor lead is also much improved in quality, the silver rendering it hard.

This process, the patent of which has expired, is followed in nearly all the mining districts of this country and in Spain, and by means of it, the revenue from all lead mines has been much increased, and the produce of silver in the United Kingdom more than doubled,—besides which, a large quantity of silver is now obtained by its application to foreign lead brought to England for that purpose, and then re-exported.

The glass case (480) contains several pieces of lead taken from the pots in the act of crystallizing, to show the forms of the crystals. It contains also a series of slabs and crystals of lead holding silver from a quarter of an ounce to 300 ounces per ton, and a plate of silver obtained from the rich lead by cupellation: this plate of silver weighs 7,703 ounces troy, or 4 cwt. 2 qrs. 24 lbs. avoirdupois. The mass exhibited by Mr. Sopwith, weighs 12,162 ounces; and the granulated silver of the Duke of Buccleuch, obtained by pouring the melted silver into water, is 140 lbs.

Safety Apparatus for ascending or descending Mines. (Exhibitors 459—471.)—To the uninitiated it may be necessary to state that the cage is a rectangular iron frame, in which the men ascend and descend pits, and in which are placed the small waggons called whirleys or hutches, containing the coal or mineral to be hoisted up to the surface by the steam-engine. In the ordinary form persons ascending or descending coal pits are liable to accidents from two causes—one, the breaking of the rope, by which they

would be precipitated to the bottom, and inevitably killed; the other arises from the cage being drawn up over the framing placed at the pit-mouth. The patent cage is intended to obviate both these causes of accidents, and does so most completely. The principle is simple, and consists of two pairs of eccentrics keyed on the extremities of two parallel shafts, which extend across the top of the cage from side to side. The edges of the eccentrics are serrated or toothed, and when the cage is in the act of ascending or descending, the eccentrics are free of the wooden vertical guides or rails which steady the cage in its motion up or down the pit; no sooner, however, does the rope slacken, as, for instance, from breaking, than two volute springs bring round the thick sides of the eccentrics to bear against the guides, and hold the cage fast instantaneously, at whatever part of the pit it may happen to be.

The other cause of accident, arising from overwinding, as it is called, is attributable to the carelessness of the engine-man, when he omits stopping the engine in time. In almost every case where this occurs, the result is fatal, as the unfortunate miners are precipitated down the pit. To obviate this contingency, the holdfast which connects the rope to the cage is secured by a curved bolt, which is kept in its place by a strong spring. The bolt moves on a fulcrum, and is continued beyond the holdfast as a lever. When this lever comes in contact with a bar placed near the top of and across the pit-head framing, the bolt is instantly disengaged, leaving the rope alone to be drawn over the pulley, whilst the cage is fixed in mid-air by the action of the eccentrics until the rope is replaced.

Mr. Fourdrinier exhibits a somewhat similar arrangement in Class 5 (406).

In the model of the plan devised by Mr. Robert Blee (459), the catches allow the cage or bucket to move freely, as long as there is any perpendicular strain upon them; but the moment this is removed, by the breaking of the rope or otherwise, the catches are liberated, and secured upon

the iron staves of the ladders, which are placed on either side of the shaft.

This model has more especial reference to the Cornish mines, where the miners always ascend and descend by the ladders. The consequence of climbing from the extreme depths of many of the metalliferous mines of Cornwall, often more than 300 fathoms from the surface, has been found destructive to the health of the miners. Stimulated by the offer of a high premium from the Royal Cornwall Polytechnic Society, two mines, Tresavean and the United Mines, have adopted machines for relieving the men. These are reciprocating rods, the men moving from one to the other, as the platforms come together. They are thus, without any fatigue, either taken up or down the mine. The expense of this contrivance has been the great barrier to its introduction, although the time saved has fully compensated for the outlay in the two mines named. In the mines of Saxony similar machines are constructed, at comparatively small cost, by the adoption of iron-wire rope.

Apparatus for lifting Pumps from Mines under Water. (Exhibitors 462, 463.)—The arrangement (463) consists of a set of wedges dropped one over the other. The wedge is passed easily into the pumps, and made fast in that position; the whole is dropped to the clack door of the lift, and turned round until the hook has entered the opening, when the rope which holds up the wedge is let go: the hook is thus safely held in the throat of the doorway, and the whole is drawn to the level of the water, and the pumps taken off one at a time. A lift of pumps, on which the apparatus was used, was 12 fathoms long, and weighed about 14 tons; but the force exerted was much greater than that required to weigh this, as the stays had to be broken, some pieces of which were oak, one foot square, and about six feet long: these were parted in two, and came up adhering to the pump.

The arrangement (462) is of a somewhat different cha-

racter, catches being brought to bear on the cylinder to be lifted. This apparatus being dropped through the water into the column, is lowered to the second pump from the top. This is done by attaching the inverted cone to the iron rods, the cast-iron block containing the cutters or tongues being kept up to such a height by two chains carried up by the side of the rods above water, that the steel points of the cutters did not project beyond the circumference of the iron block. When it is ascertained that the apparatus is fairly in the column, the chains are eased, so as to suffer the iron block to descend on the inverted cone, which forced out the tongues, so as to press against the inside of the pump; and the iron rods being attached to the capstan rope, assisted by three powerful winches, working three pair of blocks reefed with new whine ropes, the whole is weighed, safely brought to the surface of the water, and taken up, the bearers and stays being broken as before.

The ends of the tongue are well steeled, and the impressions made in the inside of the pump are not more than a quarter of an inch deep.

Model of Mineral Washing Case. (482.)—In some parts of Britanny there are immense deposits of the refuse from the mining operations of the Romans. These have been found still worthy of attention from the quantity of lead and silver which they contain; but this refuse requires peculiar management. The mode of operating may be briefly explained. The fine ore, for the treatment of which the case is especially intended, is put upon a shelf, and a stream of water, which may be increased or diminished according to the nature of the ore to be operated on, carries it with the assistance of a person to agitate it with a shovel on to a perforated plate, which should be of copper. The ore is constantly broomed on the plate to force it through the holes, which are pierced in the proportion of 25 holes to the superficial inch, and not larger than $\frac{1}{10}$th of an inch in diameter in the lower surface, and about $\frac{1}{13}$th of

an inch in the upper surface. The ore then passes on to the gutter, and is there divided by means of a movable piece of wood. It then falls on the head of an inclined plane, and is there distributed over the whole surface of the case by means of movable pieces of wood, like buttons, and is at length deposited at the head of a large trough filled with water moving very slowly, so that the heavy and valuable matter falls in the upper part of the case, and the refuse passes away to the lower extremity.

Antimony. (481.)—Antimony is a white brittle metal, exhibiting in fracture bright plates or facings, arranged in a somewhat crystalline form, but without any system or regularity. When pure, melted with suitable alkaline fluxes, and thereby protected from the air, its surfaces arrange themselves in bright fernlike crystals, radiating with much beauty and variety.

This metal is obtained almost entirely from the sulphuret of antimony, which is decomposed by fusion with iron, and purified by alkaline fluxes. Till within the last 20 years the supplies of antimony have been principally drawn from the mines of France and Saxony; but about 40 years since Mr. William Hallett raised the ore in Cornwall, and thence principally supplied England with antimony until its discovery in Borneo, which now not only supplies England, but most other countries. These mines are now in the hands of Sir James Brooke, who, as Rajah of Sarawak, raises a small Government revenue from the royalty.

The principal uses of the metal antimony are for mixture with lead and tin for printing types; with tin and copper for Britannia metal; and with tin for an antifriction alloy for bearings, &c., in machinery, it being found to become less heated where used for bearings for locomotive axles, and for collars or bearings, wherever continuous and very rapid revolution or rotation is employed.

The crude or refined sulphuret of antimony is used for medicinal preparations, in fireworks (pyrotechny), in che-

mistry, in hardening plumbago for black-lead pencils, and sometimes in dyeing. The crocus of antimony (an oxy-sulphuret) is used in France to dye (both silk and cotton) a beautiful rose pink, much superior in tint to any colour of this description produced in England. This is a subject well worthy the English dyers' inquiry and attention.

Nickel Ore, Cobalt, and Smalts (476.)—Cobalt was first employed by Christopher Schurer, a glass-maker, in 1540; and for nearly 200 years it was prepared as cobalt glass or smalts without its composition being known.

It was not till the year 1733 that the Swedish chemist, Brandt, obtained from this ore the metal which he called cobalt, and proved that the colouring matter is the prot-oxide. In 1780 Bergman confirmed and extended Brandt's results; and in 1800 the subject was taken up by the School of Mines at Paris, and investigations were also carried on by Thénard and Proust.

Metallic cobalt is a brittle metal, of a reddish-grey colour, which fuses with difficulty, and has a varying specific gravity from 7·7 to 8·7. Cobalt is magnetic, as is also nickel, with which it is almost always associated. Cobalt has not been applied to any useful purpose in the arts, and the interest attaching to it is purely scientific. The native combinations of cobalt are, oxide, and compounds of the metal with iron, nickel, arsenic, and sulphur. Nickel is employed in the manufacture of several of the white compound metals; and being usually associated with cobalt, that metal is separated in the process for obtaining the nickel. A large supply of these metals is obtained from Norway, the Norwegian mines being worked by English proprietors; they are also obtained from Hungary and the Brazils.

The beautiful blue pigment, cobalt blue, is a compound of cobalt and alumina, and the fine blues exhibited are combinations of cobalt, silica, and an alkali.

Some other examples of minerals will be found grouped around this portion of the Class, which cannot but attract

attention. Those from the collection of Mr. John Taylor are remarkable specimens, particularly the ruby and native silvers: they are mostly foreign ores.

Examples of pseudo-morphous formations from the Virtuous Lady Mine, near Tavistock (275), are exceedingly curious and instructive, as showing the changes which mineral formations undergo; those peculiar crystallizations evidently indicating the removal of the body subsequently to the formation of the case, a crust retaining the form of the original mould—which is now left as a hollow shell. These remarkable chemical changes indicate that carbonate of iron had covered cubical crystals, which had been formed on the double sulphuret of copper and iron, and had entirely disappeared, leaving cubical cavities produced by the crust of carbonate of iron. We have thus, it will be seen upon examination, several distinct actions in this lode dependent upon some change of conditions—in all probability electro-chemical. These are rather of scientific, than of industrial interest; but as exhibiting in a very striking manner the mutations of matter, they will merit attentive examination.

Platinum, Palladium, Rhodium, Iridium. (477.)—Platinum was originally discovered in the sands of some South American rivers, and from its similarity to silver—in Spanish, plata—it obtained the name of *platina,* little silver; since altered into platinum, to make it agree with the usual terminations of the names of the metals. It is now found most abundantly in the Ural Mountains, and in Russia it has been used for coins. The process of working this metal was discovered by Dr. Wollaston, as was also the means of separating the other metal with which it is almost always associated. In this case are exhibited some large vessels made of platinum, and also palladium, separated from it, both in the pure state and alloyed with silver. The great use of platinum is for the manufacture of the large boilers used for the concentration of sulphuric acid. Notwithstanding the great cost of these, they

are far more economical than any other material, as they remain entirely unacted on by the acid. In almost every form of mineral analysis platinum vessels are employed; the great accuracy now attained in that department of research being in great part due to the introduction of platinum vessels into the laboratory. Palladium alloyed with silver is used by the dentists. This metal possesses the peculiar property of protecting silver from tarnishing, by the action of hydro-sulphuric acid, even when the quantity combined with the silver is very small.

Iridium, osmium, and rhodium are also found in the ores of platinum; but, unlike the palladium, the iridium and osmium are always united, forming a native alloy of exceeding hardness, the crystalline grains of which are merely mixed with the particles containing the other metals. This native alloy, from its exceeding hardness, has been employed to form the bearing of very delicate instruments: it is separated from the platinum ore by dissolving the ore in *aqua regia*, the osmium and iridium being left behind. Rhodium remains dissolved in nitro-muriatic acid after the platinum and palladium have been separated from it. Its solutions are of the most beautiful rose colour: the mass of crystals exhibited display this in a very marked manner: its name is derived from this property.

Uranium is also associated in this case. This is obtained from certain ores of copper—*pech-blende*, *uranite*, &c. The oxide of this metal is largely employed for giving a peculiar lemon-yellow colour to flint-glass.

Metals and their Alloys. (487.)—The rarer metals, of which we have just been speaking, will be found in this little cabinet, with all the other metals. These, for educational purposes, cannot prove but of considerable value.

Arsenic. (Exhibitors 488, 502.)—The manufacture of arsenic is confined almost exclusively to Cornwall. It is obtained in an impure state from the "Burning-houses." There are kilns furnished with long flues, in which the

metalliferous ores containing arsenic are "roasted," during which operation the sulphur escapes as sulphurous acid, and the arsenic sublimes, and is afterwards condensed. It is swept out of these, and subjected to a process of purification by more careful sublimation. The white arsenic exhibited is an oxide of the metal, the metal itself being of a dark-grey colour. The uses of arsenic are extensive: it is found advantageous, when combined with some metals, for certain purposes, and it is used in glass manufacture, in small proportions, to produce transparency; in larger quantities to produce an opalescence in glass.

Gold and Silver Refining. (479.)—There are several processes by which the separation of gold and silver from the less valuable metals is effected. That exhibited is one practised in the Royal Mint refinery, and usually known as the sulphuric-acid process. In the first instance, it becomes necessary to ascertain, by minute analysis, the proportions in which the gold is combined with the baser metals, and by combination to produce an alloy of a given composition; after which this process is employed to extract gold from silver, on the large scale, more especially in France, where sulphuric acid is very cheap, and nitric acid, which is sometimes used in England, extremely dear. The following is the process:—If the alloy contain oxidisable metals, such as lead and tin, and in a large proportion, they are separated by cupellation. If their quantity be very small, they can be separated, as when copper is in excess, by an operation with nitre. Long practice has made known that the alloy which is best to act upon in the large way, consists of—

Silver . . .	0·725
Gold . . .	0·200
Copper . . .	0·075

It ought never to contain more gold, because then all the silver would not be acted upon: and not more copper, because the sulphate of that metal, which is formed, being

insoluble in concentrated sulphuric acid, would not make the alloy pasty, and secure it from the action of the acid; and there would happen, besides, jumpings and startings, which might break the vessels. The alloy, purified by nitre, is granulated, and 26¼ lbs. avoirdupois are introduced into a platinum retort, and three times their weight of concentrated sulphuric acid poured upon them, and heated gradually to ebullition; at the end of three or four hours the fire is drawn, and after one hour the liquid containing the copper and silver in solution is withdrawn, and the residual gold washed, but as it is not yet perfectly pure, it is treated a second time with sulphuric, and a third and last time by the same acid, to which a little nitric acid has been added. In a factory there are generally several alembics ranged together; a single fire is sufficient to heat three, the fumes passing into the same chimney. Above each alembic is a head, whose neck communicates with a tube leading to a channel lined with lead, the bottom of which is covered with water, and which is close to the furnace chimneys in which the nitre operation is executed: by these means the workmen are not incommoded by the sulphurous acid or by the vapours of sulphuric acid. The solutions of sulphate of silver are left to clear, and the muddy deposit which contains the gold is collected. These solutions are weakened with water until they mark at most 1·19 sp. gr. of the areometre, and slips of copper are then placed in them to precipitate the silver. It is known that the precipitation of this metal takes place but very slowly in very concentrated solutions, and the solutions of sulphate of copper, which are of higher specific gravity than the above, exercise a sensible oxidating action on the silver. The silver being separated, the copper is allowed to crystallize, forming very beautiful crystals such as those exhibited.

Safety-fuse and Blasting Cartridges. (Exhibitors 424, 519, 520, 526.)—The introduction of the safety-fuse in the mines of Cornwall has been the means of saving a large

amount of human life. By the rude method of conveying fire to the charge in the hole bored in the rock, in the ordinary process of blasting, it frequently happened that an explosion almost immediately ensued, and the miner was killed or injured in consequence. The safety-fuse is now extensively made by machinery: string being coiled so as to form a cylinder receives the powder, which is especially manufactured for this purpose, and enormous lengths are constructed by this continuous operation. In practice, the charge of powder is placed in the hole, and the required length of fuse carried down to it. The hole is then filled in with sand or broken rock, which is firmly rammed down; the fuse passing out at the top of the hole. When all is complete, the miner lights the ends of the fuse, which, burning slowly, allows him to get away to a considerable distance before an explosion takes places. In the blasting cartridges, it appears an elastic substance is placed on the upper part to prevent the possibility of explosion in the process of "tamping;" and the safety-fuse is united with the cartridge to afford facilities in use. These, when employed in wet ground or under water, are coated with pitch, or sometimes with gutta-percha.

Cinnabar. (522.)—This is the ore from which the largest quantities of mercury (quicksilver) is obtained.

This curious fluid metal is found in many parts of Europe: the principal mines being those of Idria, in Austria; of Almaden, in the province of Manche, in Spain; and the mines of the Palatinate, situated on the banks of the Rhine. There are also some mines in Hungary, in Bohemia, and some parts of Germany; but the quantity they produce is comparatively small.

The great use of mercury is for the purposes of amalgamation—separating gold and silver from the ore—in the New World. The mines of Guanca Velica, in Peru, has afforded considerable quantities of mercury, and some, but not large quantities, have been found in Mexico. In the northern part of California are some extensive deposits of

the cinnabar exhibited, which if productive must prove of the utmost importance to that gold-producing district.

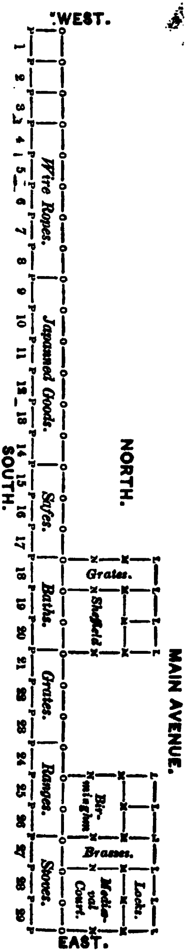
The quantity of mercury employed in the amalgamation process may be judged of from the fact, that, when the mines of Mexico were in full work, 2,000,000 pounds were annually employed.

The mercury is separated from the cinnabar, which is a sulphuret of the metal, by a distillatory process: 7,560 grains of the ore exhibited is said to have produced 5,160 grains of mercury.

Model of Gold found in California.—This is a fac-simile of one of the largest lumps of gold ever found in the gold washings of California. The original mass is the property of the Bank of England, and is exhibited in the Central South Gallery, in the case of gold and silver manufactures belonging to Messrs. Garrard and Co. It is instructive, as showing the size to which gold may exist in the lode to produce a rolled pebble of the size of the model exhibited.

Class XXII.—General Hardware, Part I.; including Locks—Birmingham.

Situation of Class 22. *It commences from the Main West Avenue with the Mediæval Court; occupies a frontage between the Pillars* L. 29 *and* 24, *the space allotted to Birmingham being the square between* L. M. *and* O., 27 *and* 24. *It extends along the Central South Avenue from the Australian and Canadian Courts to the Western end of the Building, Sheffield occupying the space between this and Main Avenue marked by the Pillars* M. *and* O., 18 *and* 21.



Position of Groups. (Numbers referring to Pillars.) —Locks, L. M. 28, 29.—Iron and Bronze Castings, L. 25, 26.—Mediæval Court, M. N. O. 28, 29.—Brass Furniture, L. to O. 27.—Birmingham wares, L. to O. 25, 26.—Sheffield, L. to O. 18, 19, 20.—The Corridor, from O. P. 2 to O. P. 29, is occupied by Exhibitors of Stoves, Kitchen-ranges, Grates, Gas-stoves and Burners, Baths, Safes, Japanned Goods, Wire Ropes, and Brass Furniture in General.

This Class has been associated with Class 1, as representing the results of human labour exercised upon the mineral productions. This extensive Class is situated most conveniently near the Class of Mining and Metallurgy.

It will be obvious to every one, that, in dealing with the numerous articles within this group, it is quite impossible to do more than name the particular groups of objects. Slight peculiarities in particular examples cannot be noticed: this is the less important since, in most cases, the articles speak for themselves. It will be of course necessary sometimes to allude to a special peculiarity, but, in doing

this, every care will be taken to avoid any invidious distinction. It must be remembered that the Handbook is intended to be purely descriptive, and, it is hoped, instructive; therefore, neither censure nor praise should be found in its pages. This explanation is necessary, since the attention of the Editor has been, in nearly every case, called to the peculiar merits of this or that construction; but these he desires to leave to others, contenting himself solely with the descriptions of manufactures.

Locks of various kinds. (Exhibitors 646, 647, 648, 649, 650, 652, 653, 654, 655, 657, 659, 660, 661, 663, 671, 672, 673, 674, 675, 678, 679, 680.)—To describe the peculiarities of the various kinds of locks exhibited within this group is obviously impossible. The principle upon which all locks depend is the application of a lever to an interior bolt, by a communication from without, so that, by means of the latter, the lever acts upon the bolt, and moves it in such a manner as to secure the lid or door from being opened by any push or pull from without.

The security of locks, therefore, depends upon the impediments we interpose betwixt the key and the bolt. These are called *wards*, and by the number and intricacy of those a good lock is generally distinguished. These wards should in an effectual manner preclude the access of any other instrument except the key, to be perfectly secure, and this is accomplished in but few locks. The locks exhibited display a large amount of ingenuity, and, as illustrations of smithery, must be regarded with much interest. Wolverhampton and its neighbourhood is peculiarly the district in which locks are manufactured. It is a curious point, showing the division of labour, that making of keys in their rough state is, in most cases, made a separate branch of industry.

The specimens to illustrate the rise and progress of lock-making (663) are instructive. In this historical series of locks we find Roman, old French, Mediæval, and old English. At the top of the central pillar there appears

the arm of a lever, which communicates, by hidden works between each disc, with every lock on the stand, and, by one movement, shoots the bolts of 37 specimens. As the production of a working man this will have especial interest. The same exhibitor has some ingenious and novel locks associated with those.

After the improvement of warded locks, we have the introduction of *tumblers*, a kind of latch, which, acting by a spring, detains the shot-bolt in its position until a key lifts it from its place and leaves the bolt at liberty. Tumblers are introduced in a variety of shapes, and in varying numbers, but in all of them the principle is the same.

The principle of Bramah's lock consists in a complex arrangement of slides, which fall into notches in a shot-bolt, and detain it in that position until they are removed from their position; but as each of these sliders has a peculiar motion of its own, and as every one will retain the bolt, the amount of security it affords is very great. The last well-known working improvement was that effected by Chubb and Hunter, and consists of a new arrangement of some of the old features, and the introduction of an entirely new one, called "the detector." Improved by the patentees at various times since the first invention, Chubb's locks now consist of six distinct double-acting tumblers, which each require lifting to a fixed position, neither under nor over, before they will allow the slot of the bolt to pass. There are no means of ascertaining the precise lift of either of the tumblers, and much less chance of hitting upon the required lift of the combination, so that, even so far, the Chubb lock has its advantages over those constructed with fewer tumblers. The "detector," as its name implies, is an arrangement by which an attempt to open the lock by the intrusion of a wrong key is made palpable to the owner of the right one, for if a tumbler be lifted out of its place, the detector spring catches it and holds it in that position, and when the right key is introduced, the failure of its action intimates the attempt at surreptitious en-

trance. To release the tumbler and allow of the shooting of the bolt, all that is required is the backward turn of the true key. The varying changes which it is possible to introduce into these locks almost defies calculation, so that in addition to the security afforded by their formation, it is almost possible to supply every man in the kingdom with one which no other key but his own shall open. We have in Bramah's locks a combination of the horizontal and rotary motion with sliders, and in Chubb's an extension of the number and improved action of the tumbler, with the addition of the detector. The principles here broadly stated are found more or less in nearly every improved lock made public within the last few years, and we know of none which can boast of being more than a variation of one or other or all of these principles.

Iron, Bronze, and Brass Castings, and numerous others introduced in ornamenting manufacture. (Exhibitors 486, 381, 340, 641.)—The ornamental metal castings of this country have not been hitherto in any way remarkable. The bronze castings of the French and the iron castings of Prussia have exceeded the productions of any British foundry in delicacy of execution and correctness of design. The delicacy of the iron castings of Berlin has led to a belief that some peculiarity existed in the iron ore employed, and that the remarkable sharpness was due to phosphorus or some such element producing fluidity. There are, however, good reasons for believing that the effect is due entirely to the very high temperature to which the metal is brought previously to casting, since it appears that even English iron is often employed to produce the ornamental castings of the Continent.

An examination of the works from Coalbrook dale, and the numerous small castings from other districts, which are to be found on the grates, mantel-pieces, railings, lamps, &c., sufficiently prove that the attention of the English manufacturer is awakened to the importance of associating art with manufacture—of giving forms of beauty to those

objects which are intended for the most familiar uses. It may be sufficient to state here that these castings are all produced in moulds of sand, the sand being selected of a peculiar and fine character when required for delicate works. The bronzes are compounds of copper and tin in variable proportions. The or-molu works are copper and zinc, or brasses. In some of the examples the original colour of the metal is retained, in others it is coloured by the lacquer which is applied.

BIRMINGHAM.

Passing by the Mediæval Court, by the Coalbrook-dale specimens, we arrive at the section devoted to Birmingham manufacture, the importance of which demands an especial section.

The greater part of the articles most commonly manufactured at Birmingham are not produced in extensive factories in which large capitals must be employed for the erection of machinery. Almost all the small wares of the district are made by workmen, who undertake, each one in his particular line, to execute orders received by the merchants and agents settled in the town. The profitable performance of their contracts, however, calls for the employment of a cheaper kind of power than is at the command of men who, like these workmen, have little or no capital; and this course of business has opened a channel for the employment of money in the town, in a manner which is found to be profitable to those who engage in it, and advantageous to the small manufacturer. The plan alluded to is this: a building, containing a great number of rooms of various sizes, is furnished with a steam-engine, working shafts from which are placed in each apartment, or workshop, which is likewise furnished with a lathe, benches, and such other conveniences as are suited to the various branches of manufacture for which the rooms are likely to be needed. When a workman has received an order for the supply of such a quantity of goods as will

occupy him a week, or a month, or any other given time for their completion, he hires one or more of these rooms, of sizes and with conveniences suited to his particular wants, stipulating for the use of a certain amount of steam power. He thus realizes all the advantage that would accompany the possession of a steam-engine; and as the buildings thus fitted up are numerous, competition on the part of their owners has brought down the charge for the accommodation they offer to the lowest rate that will ensure to them the ordinary rate of profit on the capital employed.

At the same time as this peculiarity exists in this great metal mart, it must be understood that there are some most extensive establishments from which many of the largest contributions to the Exhibition have been received.

Gas Fittings, combinations of Metal, Glass, and Porcelain. (373).—Many of these are of an original kind, exhibiting some excellent specimens of sand-casting, fitting, and lacquering. A peculiarity will be observed in the shades which are suspended on the burners, which reflect, and at the same time are not entirely opaque, being formed of flint glass coated with smelt (a kind of enamel).

Metallic Bedsteads. (Exhibitors 370, 371, 372, 373). In the first series we have the peculiarity in the pillar being made out of one tube, producing a taper pillar by a new process dependent upon the expansion of metals. The union of glass, opalescent and coloured, with stamped brass-foundry, will be noted in the curtain-bands and holders: the cornices which range along the back evidence the susceptibility and ductility of rolled sheet metal to receive impressions by means of the stamp. Under the shades in front, the union of Parian with brass will be observed occasionally contrasting its delicate hue with the rich colour of the bronzed metal work. We need not here remark, that the operation of cleaning metal is the result of acid, the bright effect is produced by burnishing with steel tools, the whole

protected from oxidation by means of lac varnish applied when the metal is moderately heated on a stove. An imitation of the bronze of antiquity is given in a few minutes also by the action of acids, and its various hues, the result of after-coatings with transparent varnish, which alters its tint from a deep black to a delicate and rich brown.

Some peculiar examples will also be found down the passage, marked "*Brasses*" in the plan, in addition to those which have already been described in the last Section. Those numbered 371, consist in casting the several parts together, that is to say, the iron rods which form the head and foot rails, being bent into proper form, they are laid in moulds having ornamental portions sunk therein, and the various joints are united by filling the same with melted iron, which effectually holds them together: it is a cheap and clever mode of effecting a union of parts.

Birmingham brass manufacture is a striking feature demanding some notice. Brass is composed of copper and spelter, varying in its composition according to the purpose to which it is intended to be applied; when melted it runs with facility into sand-moulds; when cast into ingots it can readily be rolled into sheets, drawn into wire, formed into tubes, pressed into the most complicated forms; can be filed and turned, bronzed or cleaned by acids.

Moulding is employed to produce the article in its rough state, and may be said to be the first stage of the work; previous to this, however, the pattern has to be made, and if an ornamental one the aid of a designer, modeller, and chaser will be required; the first of which makes a drawing, the second a fac-simile in wax, which is cast in lead, and committed to the hands of a chaser, who repairs it, and having a cast made in brass puts in all the details: this is then sent to the moulder, with a box formed in two parts, which he separates, and one-half of which he places with the face downwards upon a board. If the pattern is

flat he lays it in, and after riddling sand upon it, fills up the remainder, pressing it hard down: having scraped off the sand which is not required from the top of the box, and introducing another board, he reverses the same; having dusted the face he places the other half of the box on the top, and repeats the operation of filling with sand. This done the two parts are separated, the pattern or model removed, "a gate" made for the introduction of the melted metal: the box is then closed, held together with screws or clamps, and the metal which has been melted in an air furnace and in a clay crucible is poured down into holes of the box, and fills every portion of space left unoccupied, thereby producing a perfect copy of the model. Holes are cast into articles by the introduction of pieces of sand, technically called "cores." The casting is now placed in the hands of the workman; if round it is turned in the lathe, if square or flat it is filed, if an elaboration of detail, such as leafage, figures, &c., it is rifled and chased up. The appearance of dead gold is given by immersion in acid; the bright portions by means of steel tools or burnishers; and the final touch or operation is the protection from tarnish or oxidation, by means of lac varnish, which is applied with a camel-hair brush, the article having been previously heated. Bronzing is the result of the action of an acid, and its colour or shade is determined by the varnish employed as a protection, the article having previously been brushed up with black lead.

Gas Chandeliers, Stands, Lamps, &c. (Exhibitors 300, 32, 340, 343, 346, 348, 349, 351, 355, 373.)—The Exhibitor (323) first applied Parian china in connection with brass. Many of his objects will throw some light on the art of sand-casting, all such articles as are included in this section being produced by the process we have described.

Metallic Pens. (Exhibitors 324, 325, 326, 327, 328, 338, 339.)—Metallic pens have long been occasionally employed, but the extensive introduction of steel pens may be said

to have taken place since 1828, when Mr. Gillot invented a machine for making them, and 1830, when Mr. Perry overcame the difficulty of stiffness by the use of apertures between the shoulder and the point. Since that time the improvements have been very numerous, and the consequent manufacture greatly increased. It has been estimated that the quantity of steel made into pens annually is nearly 150 tons. In one establishment only in Birmingham 500 hands are daily employed; of these 400 are females. The process of the manufacture cannot be better described than in the words of a steel-pen manufacturer:—

"The history of a steel pen is among the wonders of the present day; it is to us what pinmaking was to our ancestors—a thing to be wondered at. We have the ore smelted and converted into iron, and the same changed into steel; then it is rolled into ordinary sheets, in which state it is received from Sheffield, when it is cut up into strips, pickled to remove the scale, and reduced also by rolls to the requisite thickness. In this condition it is passed into the hands of a female, who is seated at a small press, worked by hand, and who cuts out with a single blow a thin flat piece of steel, which is the future pen; side-slitting and piercing then follows, which is also performed by hand-press, fitted up with punch and bolster; thereafter the blanks in this condition are annealed in considerable quantities in a muffle; stamping with the maker's name then follows; pressing into the concave form is the next process, and the operation of forming the barrel (if a barrel pen) is now completed. Hardening—an operation which requires no little care and attention—is also performed by heating in a muffle, and when at a proper heat they are immersed in oil; the oil is then cleansed off them by agitating in a cylinder, and scouring follows by the same method, with the exception that pounded crucibles and other cutting substances are introduced along with them, which in the end produces on

one and all a bright surface. The grinding on the point, &c., is performed on an emery wheel, and is effected with great rapidity. In this state the pens are passed to the "slitter," who is provided with a pair of cutting tools, which are fitted into a hand-press. Their accuracy in fitting is such that a careful examination is necessary to detect that they are not one. The pen is rested upon the portion attached to the bottom of the press, the handle turned, and the slit is made. The slit of blue and straw colour with which the pens are ornamented is also produced by heat; the pens are introduced in large quantities into a cylinder which is made to revolve on a charcoal stove, and the change of colour is watched; when that which is desired is obtained, the cylinder and its contents are removed. The brilliant appearance of the external surface is given by lac dissolved in naphtha; heat is thereafter applied, when the spirit is evaporated, and the lac alone remains, lending to the pens that brilliancy of finish which adds so much to their appearance."

Pens are also manufactured and exhibited in gold, palladium, alloys of gold and silver, and silver pens pointed with the native alloy of osmium and iridium, already named in Class 1.

Buttons. (Exhibitors 278, 279, 281, 282, 283, 284, 285, 286, 287, 289, 290, 295, 300, 302, 305.)—*Metal Buttons* are now cut out of rolled metal, which, received in sheets, is cut out in blanks or flat circular discs of metal; the eyes are made of wire, bent into forms by a machine, and are attached to the other portion by soldering; they are then trimmed up, gilt with amalgam of gold, and burnished by hand. The metal buttons, with the raised designs on their surface, are manufactured in the same manner. The discs, which are much thinner, have the impression or design raised on them by means of a steel die, sunk in intaglio, with a correct copy of what is intended to be introduced; the die is held at the bottom of a stamp by four screws, and the reverse is attached to the falling hammer; on a

succession of blows being struck, a correct copy of the die, in relief, will be produced. This is then fitted to the back, and the two portions checked together: the rich brown bronze colour is given by means of an acid. Ordinary four-hole metal brace-buttons are cut out and pierced by means of the press. When burnished they are done by the lathe with great rapidity, as a knowledge of the price will at once suggest. *Glass Buttons* are pinched by means of a pair of pliers, having the shape of the button sunk in their mouth: the glass being melted, is easily, in its plastic state, pressed into the required form. This portion of glass is then burnished into a back, or the eye riveted in. The combination of glass and metal for buttons is effected by a very characteristic process. The metal foil is placed on a sort of iron tray, and the pieces of glass, either colourless or coloured, are placed upon this, a flux having been previously applied. The whole is now placed in a furnace, and the proper temperature being attained, the glass and metal enter into perfect combination, so that, when broken into pieces, the glass breaks off with it pieces of the metal. Having this metallic backing, the eye of the button is soldered in by the blowpipe after the glass has been cut and polished.

Horn Buttons are produced after the same manner. In its heated state horn is exceedingly well adapted to receive impressions. In the majority of instances the eye is introduced at the same time at which the impression is given.

Covered Buttons are made by means of a press, the different portions, whether of metal or cloth, being cut out by punches, the metal portions by solid punches, the other, or the cloth, by those of the same construction as is employed to form the ordinary gun-wadding, the stiff canvas and metal discs being arranged in proper order in a suitable bed, the press descends and unites the whole into one. It will, of course, be understood that this applies to all the varieties of the Florentine buttons—and

those covered with silk, satin, or leather. In 1850, in this branch of manufacture there was consumed in Birmingham of—

Florentine lasting	47,865	yards
Irish linen	3,011	,,
Silks	2,162	,,
Satins	1,182	,,
Velvets	1,017	,,
Strong canvas	26,587	,,

In addition to the above, cloth and leather with several other materials are employed in addition to the metal and button-board.

Bone Buttons, as the name indicates, are formed out of the animal substance which bears the name, shank-bones being used for the purpose, and which are cut down into thin layers by means of small circular saws, the grease or fat having been previously taken out of them by boiling. By an ingenious but simple combination of cranks, the piece of thin flat bone is held while two revolving single-point cutters cut out a disc from the portion held. The holes in the centre of the button are made by one operation: four revolving drills being set in motion, and the button pressed against them, the perforation is the work of an instant. The brilliant surface is given by whitening and rag being held against the button while it is revolving with great speed. They are stained black with logwood: other colours are also produced by vegetable or mineral substances.

Wood Buttons are cut out in the same manner as the bone variety, and by the same processes, but, in addition, they are French-polished and varnished.

Pearl Buttons are cut out from the shells of the oyster, imported for the purpose, by means of small saws of a trepan construction, which revolve in a lathe, and detach the portions which can be made useful. They are then split into horizontal layers, and rendered equal in thickness by means of a rasp. The holes are in this variety of

button made separately, and the indentations, cuts, or ornaments by small steel hobs cut on the outer circumference. They are polished by means of rottenstone, when eyes are inserted. The back of the button is perforated with an under-cut aperture, and the metal eye, with the end reduced very thin, being introduced, is tapped slightly, which expands the thin metal and prevents its removal.

At one period only the white portions of the shell were used, the other parts being rejected. With the alternations of fashion, dark shell buttons have been introduced, and those portions of the oyster which were previously rejected—that is, the outer portions of the shell—are now of considerable value. The manufacture of buttons of various kinds, in Birmingham alone, gives employment to 400 women, who are assisted by children. Men being generally employed to correct the tools and attend to the machinery.

Wire-drawing and Working. (Exhibitors 322, 332, 334, 336, 337, 353.—The rough and rude bar of iron is transformed in about a couple of minutes into a round wire rod, 100 times the length of what it originally was; and after repeated annealings and cleansing by immersion in pickle, to take the scales off, and after being passed through various holes in a steel plate, it is gradually reduced in size till it becomes almost as fine as a human hair.

The construction of plates for wire-drawing is an operation of considerable nicety, requiring the utmost delicacy of adjustment in the tools with which the holes are drilled. The art of drawing wire exceedingly fine appears to have been first effected at Nuremberg, by Anthony Fournier, in 1570; and gold and silver wire was first made in that city in 1592, by Hagelsheimer, who appears to have brought the art from Italy, and employed it for weaving and embroidering silk.

Up to the present time the process of drawing exceedingly fine wire has been most perfectly performed on the

Continent. The very fine holes for the production of the wire used in paper machines, and similar kinds of apparatus, producing a net with 22,000 meshes, is still purchased abroad.

Jewellery. (Exhibitors 294, 966, 299.)—These are peculiarly examples of the great staple of Birmingham. The contributions of this class are not large, but they will be found, for the most part, well deserving attention. The exhibition consists of chains, bracelets, armlets, finger-rings, pins, and studs. Some choice examples of filigree-work show the degree of perfection to which this class of manufacture is brought in this country. Pencil-cases, pen-holders, seals, keys, &c., complete this group.

A selection of these articles and other gold and silver work will be found in the Gallery, to which, in its proper place, attention will be directed.

Medal Die-sinking and Coining. (Exhibitors 264, 271, 273, 310.)—Dies are formed out of steel laid in some cases in iron. Small handle tools are used for cutting the matrix; the workman uses a glass the better to examine the progress of his work. The inscription is introduced by punches. Hardening of a medal die is accompanied by risk. The production of a medal after a die is sunk is an easy matter, and is accomplished by means of a large screw-press, on the top of which is fixed horizontally a balance-wheel; the blank which forms the medal is turned smooth if of block tin, and introduced into the die. Motion is imparted to the fly-wheel, which carries down with it the obverse die of the medal, imparting to the metal the impress thereof; if the medal is made of some harder metal it must have a few annealings, and a sum of blows to bring it well up.

Wood Screws. (Exhibitors 316, 318.)—These are made from iron wire; the head is raised in a die by pressure; the worming is effected by a screw, which traverses the back of the spindle, and forces the clams containing the

blank or uncut iron forward against small cutters, which rip or cut out the thread. Slitting is done by small circular saws.

Cut Nails. (315.)—These are made from sheet-iron, which is cut into strips, and is held before the chisels, operated upon by power, which nip off so much in width as is required to make a nail. A pair of grips lay hold of the piece of iron as it is disconnected, while a blow with a horizontal hammer completes the manufacture of the nail by flattening the head.

Pins. (Exhibitors 278, 335.)—Some improvements have been made in pin-making. The heads are now in general solid, not formed by two revolutions of wire as formerly. The wire is drawn by the ordinary process; is straightened by being drawn between a series of studs; is cut to lengths sufficient to form two pins pointed, in small revolving files. The rough outside being first removed by a coarse file, the wire is then smoothed by another: heading is effected after the manner described in nail-making, viz., by a horizontal hammer. Whitening is done by boiling them in tin solution; they are then dried out, selected, and papered up.

Stamped Brass. (Exhibitors 261, 263, 274, 353, 356, 362.)—These specimens consist of window cornices, curtain-bands, cornice-pole ends, all of which are made out of sheet-metal by stamping, a process which may be described as practised thus:—A steel die, having what is to be raised in relief sunk in the reverse, is placed under a stamp, between the upright rods in which a heavy mass of metal works up and down, by means of a cord passing over a pulley, to which it is attached. The die is fastened by four screws to the bottom of the stamp. To the hammer is attached the *force* or counterpart. The plate of metal to be raised is laid thereon, the hammer is raised, falls, and produces an indentation; repeated blows, and the substitution of "forces," more prominent as the relief advances, is introduced, until every detail of the die is marked. The metal is annealed between each blow. The cleansing

up is the same as is employed in punching cast brassfoundry. Another exemplification of the use of stamped brassfoundry will be found in the stamped work for gas-fittings, and the contributions of metal produced by rolling tubes, &c. Metal, when to be rolled, is cast in ingots, and is laminated by being passed through iron rolls, which revolve by steam-power. Brass or copper tubes are formed from thin sheets of metal, cut to the proper width, and rendered concave in the entire length; brought into a tubular form by being pulled through steel holes. The edges are then held together by wire; solder and borax mixed are laid along the seam, and fused by being passed through an air-furnace. The extra solder is then cleansed off by filing, and the tube drawn again through a steel hole, when the whole is said to be finished.

Needles and Fish-hooks. (Exhibitors 329, 330, 331, 334, 335.)—Needles are manufactured from steel wire. The wire is cut into lengths sufficient to make two needles; these are collected into bundles, and straightened by a peculiar process; the grinder takes a number of these pieces in his hand, and causing them to rotate on a grindstone, points them; he next reverses the ends and effects the same result. They are then cut in two, flattened on the end, and eye-punched either by children or machinery; the roughness is removed, and the eye smoothed by filing. The process can be examined in the Department of Machinery in Motion, needlemaking being carried on during the day by a very nice small machine. They are then tempered in quantities, and polished by being gathered together and made to traverse a horizontal hearth or table, and some abrasive substance lubricated with oil being introduced amongst them: scouring, winnowing, and sorting then follows.

Guns and Swords will form the subjects of distinct consideration.

Class XXII. Part 2.—Sheffield. Iron and General Hardware.

Situation of Sheffield.—*Passing out of the Section devoted to Birmingham, and walking westward past the Area devoted to Furniture, we reach that department, between the Pillars* L. M. N. O., 17 *to* 20, *which is devoted to the characteristic Manufactures of this important town.*

One branch of manufacture carried on in Sheffield has been very greatly extended during the last few years, until it has now become of considerable importance—this is the conversion of iron into steel; a process which is performed to the extent annually of many thousand tons, a considerable part of which is exported in an unwrought form. The town of Sheffield in 1835 contained 56 furnaces for converting iron into steel; besides which there were 62 establishments, containing 554 furnaces for melting steel. The original conversion of the metal into blistered steel occasioned the use of about 12,000 tons of coal in the form of coke, and the subsequent processes required about 81,000 tons in addition. The various manufactures of cutlery and plated goods carried on in the town, consumed about 200,000 tons, and 38,000 tons were the estimated allowance for the working of steam-engines, of which there were then 74, of the aggregate power of 1,353 horses. If to these quantities are added 184,000 tons as fuel for household purposes, it will appear that the entire consumption of coal in Sheffield amounted in 1835 to 515,000 tons, the whole of which was taken from collieries in the immediate vicinity of the town. Five-sixths of the iron used for manufacturing purposes in Sheffield is of foreign production; only 2,000 out of 12,000 tons consumed in the year is of British origin. Since the improvements in British iron a very much larger quantity of our own iron

has been converted into steel. The cost of the fuel forms just one-third part of the expense of converting and casting steel.

Steel. Introductory Remarks: importance of Quality. (Exhibitors 184, 187, 190, 199.)—It will be obvious, even on a cursory glance at the rest of the large collection of articles exhibited by the manufacturers of Sheffield, that the reputation of a place which has acquired a world-wide renown for the excellence of its cutting instruments, is admirably sustained, as far as *form* and *finish* are concerned, by the contributions enumerated in the Catalogue. It is necessary to make this preliminary remark, because that which constitutes so essential an element of value in the leading articles of the *cutlery trade*, for which Sheffield has been famous for centuries, viz., *quality*, is scarcely appreciable, even to a practised eye, either in the metallic material, as presented in its unwrought form, or after the successive applications of the hammer, the file, the grinding-stone, and the polisher. As, therefore, neither the firmness of saws, the durability of axes, nor the wear of files, any more than the tempering of razors, the action of scissors, or the performances of pocket and table cutlery, can be submitted to any satisfactory test of comparative merit in the Exhibition, the reputation of individual manufacturers, and the hard-earned celebrity of their common focus of industrial enterprise, may be safely left to vouch for the quality of wares, the workmanship of which is so generally and obviously superexcellent, even in articles of which *use* and not *beauty* is the leading recommendation.

It may be mentioned, in passing, that, while in the ferruginous district, anciently called "Hallamshire," and of which Sheffield, surrounded by its productive coal-works, is the modern capital, not a single ounce of iron ore is at this moment smelted, the manufacture of steel, especially so far as the conversion of the best foreign irons is concerned, is carried on to an extent not equalled in

any other part of the world. The result of all the furnaces at present in operation being not less than about 50,000 tons annually, three-fourths of which, at least, is made from foreign irons; and of the whole amount nearly 20,000 tons is exported in bars, &c., to the United States.

Of the large quantity thus undergoing the interesting process of *cementation* (187), or exposure to the long-continued action of heat in stone coffers filled with granulated charcoal, by which it is converted into *blistered* steel (190), one portion is afterwards submitted to the operation locally termed *shearing*, *i.e.*, re-heating, doubling, welding, and drawing out the bars under a tilt-hammer, until they are sufficiently condensed in texture, and reduced to the sizes required. Another portion is refined by breaking up the blistered bars into fragments, and melting them in a crucible made of Stourbridge clay; the liquid metal being then poured into an iron mould, by which means a block of steel called an *ingot* (190) is cast, and afterwards reduced, by the agency of tilting or rolling, to bars, sheets, and rods of the sizes required by the artisan. Numerous specimens of the material in these forms are exhibited (109); and they are interesting, not only as illustrating an important stage in the conversion of one of the commonest mineral products into articles, some of which surpass in their ultimate value their own weight in the precious metals, but as showing also (199) the condition in which many thousand tons of steel are annually exported to the United States. Our home-made bar-iron of the lowest quality is sometimes sold for as little as 8*l.* per ton, while the best foreign produces as much as 34*l.*, having been much higher a few years ago. The market value of the latter being increased to 75*l.* per ton, in the form of tilted bar, after conversion into best cast-steel; and as there is always in the market an indefinite number of intermediate qualities, as well of home as of foreign make, it is not surprising that the English iron-master should have en-

deavoured to bring the best produce of his own forges into practical comparison with that of Danemora and other northern mines. This endeavour, laudable not only as tending to enhance the relative value of one of our most important native sources of national wealth, but as directly lessening the dependence of our manufacturing existence on an exclusively imported commodity, has not been, by any means, neglected (258). Opportunity is here afforded for comparison between some of the most obvious desiderata of the competing products, in the attributes of compactness and clearness of internal structure—of a perfectly high polish; and, what must be admitted as a more unequivocal test of excellence, the ductility exemplified in some specimens of fine-drawn wire, an article which forms a valuable item in the iron and steel works of the present day.

The great variety of articles manufactured in Sheffield from steel indicates this as the proper place to describe the peculiarities of the various kinds employed. The quality of steel depends both on the ore and on the manipulatory processes to which the iron is subjected. Steel appears to be a compound of iron and carbon; and it is not improbable that silicon, the metallic base of flint, may form an important element in the production of good steel.

Damascus Steel and German steel are celebrated for excellent qualities. Genuine Damascus steel is made directly from the iron ore, principally a red oxide of iron—red clay ore—found in the transition slate. It is generally believed that the strength of this steel is to be attributed to a small quantity of aluminum which enters into its composition, and which is derived from the clay of the ore. The Damascus work on the sword-blades of that Asian city present upon their surface a watery appearance—a variegation of streaks of a silvery-white, black and grey colour, and fine and coarse lines, disposed in regular and irregular figures: this is produced by welding together

iron and steel, as we shall have particularly to describe in our notice of gun barrels.

German Steel is made sometimes directly from the ore, by converting the ore into pig-metal first, and then into steel. Wood is used in smelting the iron; and to this and the character of the ore, commonly bog-iron ore, its peculiar properties may be attributed.

Three kinds of steel are now principally manufactured in this country—bar or blistered steel, shear steel, and cast steel.

The bar or blistered steel is made by the process of cementation: this consists in putting bars of the purest malleable iron alternately with layers of charcoal or soot into a proper furnace; the air being carefully excluded, and the whole kept at a red-heat for several days. By this process the carbon combines with the iron, altering its texture from fibrous to granular or crystalline, and rendering the surface blistered. The action of the carbon occasions fissures and cavities in the substance of the bars, rendering them unfit for tool-making until they are condensed and rendered uniform by the operation of tilting, *i.e.*, compression by a powerful hammer worked by machinery.

Shear steel is made by breaking up bars of blistered steel into lengths of about 18 inches, and binding four or six of them together with a steel rod, and then heating them to a full welding heat, the surface being covered with fine clay or sand to prevent oxidation. They are then drawn out into a bar, hammered, tilted, and rolled. In this state it is susceptible of a much finer polish, and is also more tenacious and malleable, and fit for making strong springs, knives, &c.

Cast steel, which was first made by Mr. Huntsman, at Attercliff, Sheffield, in 1770, is made by melting blistered steel, casting it into ingots, and rolling it into bars. In this condition its texture is much more uniform, closer, and finer grained.

The different degrees of hardness required for steel are

given by the process called "tempering," which is effected by heating the steel up to a certain temperature, and then quenching it suddenly in cold water. Its hardness and brittleness are thus much increased, but it may be again softened by exposure to heat simply.

From these kinds all our cutlery, whether fine or coarse, needles, hooks, ornaments, &c., are manufactured. In our consideration of the manufactures of Sheffield, the peculiarities of steel manufacture will receive full consideration. It was not easy to place steel consistently with any especial group of exhibitors, since it is so largely employed by all in this class.

The analyses of several varieties of steel have shown that the following substances enter into its composition:—Iron, carbon, sulphur, phosphorus, silicon, arsenic, antimony, nitrogen, copper, tin, manganese. It is not to be supposed that all these materials are to be found in every variety of steel; in some one, ingredients are discovered which cannot be detected in another, and in all probability the peculiar differences in steels are due to the combination of small quantities of one or other of these elementary principles.

Stoves, Cooking Apparatus, Grates, Fenders. (Exhibitors 102, 103, 104, 105, 106, 107, 140, 189.)—Immediately on entering the Sheffield compartment, the visiter's attention is arrested by a series of stove-grates of a more or less superb character, and suited to fire-places varying from the ordinary conveniency of a respectable drawing-room to the splendour of a palace. The manufacture of these important articles has, of late years, been zealously pursued in Sheffield, by the judicious combination of capital, enterprise, and taste, which the present Exhibition must convince any one is not likely to be unsuccessful. For, next to the beauty and capability of these indispensable articles of household comfort, the comparative cheapness of all but those of the most sumptuous character may well be matter of surprise.

Those persons who are old enough to recall to mind the poor style of ornament exhibited by our best metallic fire-places, only little more than half a century ago, will best appreciate the extent of the improvement which has taken place in the article of castings alone. The elements of this advance may be ranked under the heads of model-making, foundry, and material. In the first place, not only are the outlines of the model often very graceful, but there is a depth and delicacy of detail which, secondly, it requires all the skill of a first-rate caster to bring sharply out,—including, in many instances, the difficult in under-cut and matted parts. The material in which these articles are generally moulded in the Sheffield casting-shops, is a fine red friable sand from the river Trent, near Mansfield. The specific peculiarity of each stove is indicated by the terms, register and air (102), cooking and gas (105), heat-reflecting (106), smoke-curing (140), &c. Most of these stoves are accompanied by fire-irons (174) and appropriate fenders; the latter representing a branch of trade, in which the availableness of open scroll patterns has still more largely stimulated the invention of the artist and the skill of the artisan, whether exhibiting elegant combinations of dead and polished steel, or the more subdued tones of black, bronze, and or-molu (104).

It would be useless to attempt a description in detail of a class of objects which the engraver alone can satisfactorily illustrate: suffice it then here to say, that the cheapest forms of stove-grates are mostly manufactured of black castings in iron, like parts of the cooking apparatus (105), but generally more or less ornamented with designs modelled in low relief; while the more elegant specimens, which form so attractive a feature in the Exhibition, are composed of parts in which the metal is finely got up with dead and polished surfaces; the effective contrasts thus produced being heightened by the introduction of lacquered or gilded scrolls, and the use of cast figures in bronze or other metal. Many of these productions indi-

ate considerable taste in the original designer; thus illustrating the importance of a recent law, which protects the manufacturer from the piracy of a registered pattern. It is gratifying to add, that the more spirited houses engaged in this trade, as well as in others to which art-embellishment can be advantageously applied, are availing themselves of the talents of men who have been generally brought up as professional artists, or taking into their employment young persons who have evinced appropriate capabilities while students in the Government Schools of Design.

We have been favoured by Mr. Young Michell, the Head Master of the Sheffield School of Design, with the following list of articles which are in the Exhibition, manufactured within the last twelve months, from designs by pupils of the Government School of Design:—

Description of Articles.	*Designer.*
Six stove grates	Henry Hoyles.
Six fenders	W. H. Brookes.
One grate	C. Bolland.
Three sets of saw-plates in silver and bronze	Godfrey Sykes.
Two sets of tortoise-shell combs	H. Archer.
Carved knife-box	A. Hayball.
Silver candelabrum	William Ellis.
A sideboard carved in walnut, 10 feet in length, and 7 feet high (This work has been designed and executed at an expense to the pupil of about 180*l*., and expressly for the Exhibition of 1851.)	H. Hoyles.
Carved cabinet in walnut, 8 feet 6 inches high (Designed and executed by the pupil at an expense of between 50*l*. and 60*l*. for the Exhibition of 1851.)	A. Hayball.
Full-length figure, intended for the figure-head of a yacht	William Ellis.
Model for plateau	H. Archer.
	Modelled and Engraved by
Three daggers, with embossed silver sheaths and engraved blades	William Ellis. Godfrey Sykes
Inlaid mantel-piece in Derbyshire marble	—Lomas.

The annexed list shows how far what we here call the higher walk of art manufacture, namely, originating designs, has been supplied from the school; but the practical uses of the school extend much further. Not one manufacturer who has exhibited articles in iron and silver, in the manufacture of which ornament enters, but has not, in some degree, benefited by the school. The whole class of artisans, such as chasers, engravers, model-makers, stove-fitters, Britannia metal-workers, mask-makers, &c., &c., &c., have all contributed their quota towards the artistical excellence of the works exhibited. A manufacturer having a good design has made a great step; but what can he do unless those who are to carry out the designs be, to a certain extent, artistically educated? The repeating or counter-modelling of any artistic work requires very considerable artistical ability, and the school alone could furnish it. Of this fact the manufacturers themselves are not unaware, and hence arises that manifestation of improved taste which is evident in modern British manufacture.

Railway Carriage and Coach Springs, &c. (Exhibitors 109, 160, 190.)—The use of steel for the springs of ordinary travelling carriages is of long standing; but an enormous increase in its consumption for such purposes has been created by the modern railway system. Of the benefit and enterprise of this new staple Sheffield has fairly partaken, and specimens of her skill are here exhibited. This is a proper occasion to remark, that, as it is impossible to obtain in steel of minimum cost those rare conditions of tenacity and elasticity combined, which constitute excellence in a carriage-spring—and as the quantity of material entering into the formation of those which support locomotive vehicles especially, affords so strong a temptation to substitute cheapness for goodness—too much stress cannot be laid upon the moral duty, to say nothing of the manufacturing policy, of endeavouring to keep before the public the supreme importance of *quality* in an article of comparatively easy fabrication, but upon which the lives

and limbs of so many thousands of persons all classes daily depend.

Anvils, Vices (226), *Carriage Axles* (204A).—In the two former of these articles—the most ancient tools of the smith—we look rather for good material and good workmanship, on unchangeable patterns, than for elegance or novelty; while the third-named article represents a manufacture of considerable importance viewed in relation to vehicular statics, and the economy of animal power: indeed, the large extent to which turned iron-axles working in carefully-fitted metal bushes (166), have superseded wooden ones, even in common carts and waggons, is a striking exemplification of an improvement which, despite the natural predilection in favour of cheapness, has found its way from the fashionable coach-house to the humblest farm-shed.

Edge, Plantation, Gardening, Joiner's, and other Tools. (Exhibitors 110A, 112, 113, 128, 169, 179, 182, 204, &c.)—Passing from articles formed mostly of black steel, or that state in which they appear as mostly finished by the hammer, we come to a large series of examples of tools, the surfaces of which are partially brightened by the grinding-stone which gives the edge; or, rather, such was the case in respect of most of the old-fashioned instruments of each class; for so considerable has been the effect of taste and competition at the present day, that those parts of spades and hoes, as well as of adzes and chisels, which used to be left unground, or were blacked by the application of some cheap carbonaceous matter, are commonly bronzed or blued, if not actually polished. Many of these articles, indeed the bulk of the edge-tools (192), technically so called by the trade, exhibit a high degree of perfection in form and finish. Scythes, sickles, and reaping-hooks (204), which are here represented in each class, are not only largely manufactured in Sheffield, especially those which can be formed in part of sheet-steel, but a great number of persons are employed in making

them in the rural hamlets, a few miles south-east of the town, where the trade has flourished since the settlement of numerous fugitive workmen, who came over from the Low Countries in the time of Queen Elizabeth (214, 215). There are a number of miscellaneous articles, exhibiting much perfection in the manufacture—from the ponderous screw-augur of the shipwright (187), and the curious archimedean shearing-knife of the clothworker (109-113), to the diversity of awl-blades (145), heckle-pins and sewing-needles (115, 164, 284)—the latter not to be despised for their minuteness or comparative simplicity of shape, so long as they continue to form indispensable adjuncts of laborious occupations, even amidst the marvellous triumphs of machinery in the nineteenth century.

Files. (Exhibitors 109, 113, 160, 161, 163, 187, 190, 191, 193, 207, &c.)—An important item in the display of non-polished steel articles is files, the value of which, in their relative degrees of excellence, is fully appreciated by at least every artificer in metal, from the engine-smith to the watch-movement maker. To the mere uninitiated inspector of an assortment of hardware, a common file is perhaps as little attractive as any tool can be; yet, even here, manipulatory skill and taste have executed ingenious designs (161.) Nor are these pictures delineated by the ordinary workman, with hammer and chisel on steel, merely indicative of wasted ingenuity, meaning nothing; they illustrate, in combination, that great variety of styles of cutting or raising the teeth, which is displayed in the serial array of useful files, and in which so material an element of success in this manufacture consists. It is, indeed, chiefly in this character, and that of general outline, that a file presents any features of visible excellence. The essential qualities of a fit material, and judicious tempering, upon which the value of a file, more than perhaps any other accessory of handicraft, depends, can only be estimated by the criterion of actual use.

It is almost impossible for an ingenious individual to

look at such a collection of files as this without asking himself the question—Could not the cutting be done by machinery? It may suffice here to say in reply, attempts to produce such a result have repeatedly been made, but have all turned out unsuccessful in practice; indeed, it is remarkable, that with the exception of the grinding department, and even here the mill aids, but does not supersede, the hand, nearly the whole of the beautiful and useful productions of the Sheffield workshops may be said to be the result of manipular industry. The dexterity required in some departments, as the development of a scissor-bow with a hammer, on the anvil (194), is very considerable. In this view, it forms a striking contrast to compare a few inches of plain net-lace, and the complicated machinery by which it is produced, with the richly-wrought scissors (175), or the razor (114), and the few cheap and simple tools used in the manufacture of these articles. Between three and four thousand workmen are engaged in the Sheffield file-trade.

Saws, Plates for Engravers, &c. (Exhibitors 109, 113, 147, 191, 192, 193, 204, 208.)—Saws, of far more general use than files, at least out of the workshop, may be mentioned next, presenting as they do a greater breadth of polished surface, in the Sheffield quarter, than any other product of that town. Their large size and curious variety, almost as much as the high finish of handle and perfect polish of surface which many of them exhibit, force upon us at once an idea of the extent and perfection of this important branch of trade, in which at least five hundred individuals are constantly employed in Sheffield. Of course, saws, as well as edge-tools and files, must owe their best praise to excellence of material; but still in the quality of their toothing, and, much more, in the execution of the difficult operations of hammering and grinding, external effects are produced which indicate a wide difference between the perfection of many of these articles and those of an inferior class of workmanship;

indeed, that material excellence, a surface without waviness, must be very apparent, even in the largest circular (113, 191) and pit saws, as well as in many of the ground-steel webs of smaller size. It may be mentioned, that not only is the toothing and polishing of saws effected by the aid of machinery, but some curious mechanical contrivances have been devised for aiding the grinder to produce that perfectly level surface above alluded to. The apparent purity of material, the perfect planishing, grinding, and buffing exhibited in the unusually large circular-saw and several others, are conditions of excellence of the highest value in another article of rolled-steel, for which Sheffield is also noted, viz., plates for engravers; the manufacture of which, when they are of large size, is one of extreme delicacy and difficulty. A large steel plate of this class, machine-ruled, with very fine parallel lines over its entire surface, is placed in the Department of Fine Arts (147), along with an impression from it taken on paper; thus exhibiting and illustrating with extraordinary effect those rare qualities of surface upon which the success of the delicate and costly operations of the etcher and the engraver so immediately depend.

Table Cutlery. (Exhibitors 116 to 121, 130, 133, 136, 155, 156, 162, 195, 203, 220.)—The knife ordinarily in use at table in this country, at present, is of the plainest shape; neither fashion nor convenience demanding that curious diversity of outline in the blade which some old sets exhibit: hence, good quality of metal and superior excellence of workmanship are the chief criteria of value. In other respects the modifications are endless. Of table-cutlery a great variety of sorts are here exhibited, from the "Sheffield Whittle" (120) (perhaps something like that mentioned by Chaucer), to the finest modern patterns (110); presenting, however, the most striking diversity in the form and material of the handles, including horn, bone, wood, and ivory, the latter being most generally used in mounting the better services for the me-

tropolitan and other markets. It will give some notion of the extent of this important trade, in its appropriate locality, to state, that the quantity of ivory cut up by the "hafters," as the handle-makers are called in Sheffield, is between sixty and seventy tons annually, being little less than one-fourth of the whole quantity imported into this country. The best table cutlery is made from shear-steel, and the forging, filing, grinding, and hafting of it, employs a great number of hands in that emporium of industrial ingenuity whose products are now under notice; the number of men engaged in the forging of blades at the anvil being about 700; of grinders, including boys, 900; and of hafters, 1,300. It is in the dry-grinding of forks, especially of a cheaper kind, produced by sand-casting, that the workman often contracts a pulmonary affection through inhalation of dust and metallic particles, called "the grinder's complaint," the nature, fatality, and prevention of which have frequently engaged the attention of the philanthropist, as well as the inquiries of members of the medical profession.

A disposition to supersede the common steel fork by one of three or four prongs, and with a silvered surface, has been greatly encouraged by the invention of electro-plating, several beautiful specimens of this article, as well as of knives plated on steel, being exhibited (110, 131, 142).

Spring-knife Cutlery. (Exhibitors 117, 137, 139, 143, 144, 147, 149, 159, 198, 224, 225, &c.)—Of the ample variety of forms into which manufacturing ingenuity has moulded the pocket and pen knife, it is impossible to do more than speak in very general terms; indeed, the quality of the blade is so all-important, as compared with the form or the material of the handle, in these universally useful articles, that fancy and price, rather than taste or art, claim to be mainly considered by the fabricants. It will be seen that in addition to the substances used for *scales* or covering of handles, men-

tioned above, the maker of jointed cutlery uses stag-horn, pearl, and tortoise-shell. It is considered that the value of the materials here alluded to (that is, inclusive of ivory), amounts to not less than 99,000*l.* annually in Sheffield alone.

Razors. (Exhibitors 114, 117, 132, 134, 135, 139, 149 to 156, 188, 197, 203.)—In calling attention to the article of razors, for the manufacture of which Sheffield enjoys so wide a celebrity, we must not allow ourselves to be diverted more than a moment by those giant specimens, which, whatever beauty and perfection of workmanship they may display, are wholly useless for that purpose, which makes the daily personal comfort of so many thousands of males to depend upon the quality of an ordinary-sized razor. In common with the first class of surgical instruments, for incisory purposes, good razors are commonly made of the best and hardest quality of cast-steel, *i. e.*, Swedish iron of the highest class, and of the maximum degree of carbonization; it must, however, be obvious, that whatever the primary excellence of the metal out of which the blade is formed, the greatest caution is required to avoid spoiling it in the successive operations of forging, tempering, or grinding, to mismanagement in one or other of which the defectiveness of many expensive razors is ordinarily to be referred. The number of men employed at the anvil in this branch is about 160; a *maker* and *striker*, as in table-blade forging, working together in alternate strokes with different-sized hammers.

Scissors; Shears. (Exhibitors 124, 126, 133 to 139, 165, 175, 194.)—Under these numbers are exhibited numerous forms of garden (124, 168), sheep (122, 127), and tailors' shears (157), most of which are composed of shear steel and iron welded together at the anvil. The dexterity required to develop a scissor-bow out of the solid steel, by means of the hammer, has been already alluded to, and is exemplified in 194; the operation, however, is equally applied in the production of a pair of scissors, the value of which is

twenty guineas, or half as many farthings (175). It is in this class of articles that the Sheffield cutler appears to the greatest advantage in the ornamentation of steel-work, in connection with purposes of direct utility. Most of the elaborate designs in this interesting department are developed from a solid shank by the successive application of the file and the chasing-tool, involving an immense expenditure of time and of manual skill. Nos. 175 and 194 are marvels of success in this operose ingenuity, which cannot be said to be wholly misdirected or useless, so far as it belongs to a style of workmanship still in demand in the labour market of the Yorkshire Damascus: perhaps, however, most persons of taste will concur in opinion with those who regard a pair of plain, well-formed, and perfectly-polished women's scissors as the most elegant production of the Sheffield workshop; nor is there any article which so utterly distances all foreign competition, whether the criterion of excellence be the smooth and effective action of the blades, the perfect finish of the work, or both together. About 900 men and boys and 200 women are employed in the manufacture of scissors.

In the Central Avenue, and nearly opposite to the General Sheffield Department, stands a separate glass case, filled with fine cutlery, from the same town, and including many exquisitely-beautiful specimens of most of the articles already described. This trophy is terminated by a large spring-knife, containing 80 blades, and which, although sufficiently attractive as a curiosity, and for its admirable workmanship, is mainly noticed here for the effective ornamentation of its polished surfaces, by means of etching on the steel with aquafortis. This style of work, striking examples of which may be seen on the blades of razors, and other polished articles, is displayed on this large knife, so as to produce a very varied and artistic effect, especially when viewed sufficiently near. The number of persons employed at this time in Sheffield, in

different branches of the spring-knife cutlery department, is about as follows :—Blade, scale, and spring forgers, 250 to 300 ; grinders, 500 ; men and boys at workboard, 2,500. It may be remarked, with reference to the finest classes of these articles, that, contrary to what might have been expected, the introduction and general use of steel pens is said to have affected but little, if at all injuriously, the pen-knife trade, while a new source of industrial employment has been opened to the manufacturer of sheet-steel, as well as to the metallic pen-maker.

Sheffield Plate has been long celebrated ; but as the best examples of this manufacture are arranged in Class XXIII., the notice of the processes employed is reserved for that division.

Passing out of the Area devoted to Sheffield towards the south, we enter the department devoted to IRON and GENERAL HARDWARE. *This Section extends from the Pillars* O. P. 3 to 29.

Wire Ropes. (Exhibitors 30, 36.)—The application of metallic wires to rope-making, although absolutely as old as 1822, was never successfully made till 1835, when the late M. Albert, Director-General of the Hartz Mines, established a method of manufacture which resulted in the most unqualified success. M. Albert perceived that for the wire to retain its strength it must be laid into ropes without *receiving any twist whatever round its own axis.* This principle once fairly taken up, the making of wire ropes by a manual operation little more advanced, as a manufacturing process, than that of fishermen, was at once adopted. Specimens of wire-lines for their own use were circulated throughout Germany ; and the economy of iron-wire ropes for mining purposes was substantially proved.

Wire ropes *made of untwisted wire* were not introduced into England until Mr. Newall obtained his patent in August, 1840, for machinery which perfectly effects all that M. Albert contended for. About the same time, M. Vegni introduced the manufacture into France ; and

Mr. Newall's machine was adopted in Saxony and in Austria. Besides the adaptation of machinery for the manufacture of wire ropes of untwisted wire, their introduction into this country was accompanied by an important improvement *in the structure of the ropes.* M. Albert's ropes were invariably made of sixteen wires, four wires in each strand, and four strands in each rope, as exhibited in one of the specimens deposited by Messrs. Newall. This construction did not allow of sufficient variety of sizes of rope without inconveniently increasing *the dimensions of the wire.* The patent wire rope is composed most usually of *thirty-six wires,* six wires in each strand; these six wires being symmetrically laid round a hempen *core*: then there are six strands in each rope laid round a hempen core. By this method of manufacture, the thirty-six wires are kept equidistant from the centre of the rope, and are therefore all of the same length. Each, therefore, is subjected to the same strain—has the same amount of work to do; and as they are laid without any twist in themselves, the greatest possible strength is obtained from the amount of material employed. This is the whole principle of the manufacture. We regret that the machinery has not been exhibited. There are, however, specimens of all sizes, varying from wires whose breaking strain is 20 lbs. to ropes whose breaking strain is 180 tons. The use of wire ropes has gradually extended since 1840, and is now very general. Flat and round ropes are used pretty universally in the Northumberland, Durham, and Yorkshire coal-mines. There are upwards of 200 miles of inclined planes of railways worked by wire-rope. Inclines are being substituted for *locks on canals since the introduction of these ropes.* The application of wire rope to the standing rigging of ships is slowly but gradually advancing, as its many advantages over hemp in cheapness and security become known. In short, metallic wire rope is superseding hempen rope for innumerable technical purposes.

Chains. (Exhibitors 51, 75, 76, and 401, Class I.)—Until

within a comparatively very recent period ropes were entirely used in mines, and it was not until during the continental war, when the price of hemp, which was chiefly supplied from Russia, was excessive, that any attempt was made to introduce any other material. It will be evident upon consideration that iron chains would offer themselves as the substitute; but in these many difficulties had to be overcome. The iron links had to roll over a drum in winding and unwinding, during which the ordinary chains being disposed to twist were liable to snap whenever a sharp turn took place. Hence it was necessary to secure great toughness in the metal, and use much caution in the welding, to prevent the iron from undergoing any change.

Mr. Edge introduced the flat chain with wooden key, which has been eminently successful, and is now generally employed in our collieries; and where they have been obtained from careful manufacturers, and used with care, they have never failed. The exhibitor (51) states that no loss of life has been occasioned by any chain of his manufacture during the period of 39 years. Shafts have been driven by this agency to the depth of more than 270 yards; and the chains afterwards used for terms varying from four to six years. The specimens of chains shown in this and in Class I. sufficiently illustrate the general characters of the chains used in our mines for winding and other purposes.

Iron. (Exhibitors 83, 84, 85.)—The ores of iron are described in connection with the exhibition of them in Class I.; it therefore only now remains to notice a few peculiarities in the manufacture of iron, and in the results obtained.

The ores of iron commonly consist of an oxide of that metal combined with some earthy matter; the result, therefore, of fusing these alone would be the production of a kind of glass. It becomes necessary, therefore, to mix the ironstones with such substances as, during the

process of fusion, will combine with the oxygen and earthy matter and set the metal free. From the great affinity of carbon for oxygen, forming carbonic acid gas, charcoal and other carbonaceous substances are very largely employed; in addition to this, it becomes necessary to use some material which shall combine with the calcareous, silicious, or aluminous matter with which the iron is combined. In some cases this is effected by combining ores of dissimilar characters; but ordinarily some flux, such as lime, is introduced.

An ordinary iron furnace will make about four tons of cast iron in twelve hours: or the production of this quantity of metal there are required about seven tons of coke, eight tons of roasted ironstone, and rather more than three tons of limestone as a flux. Some of the large furnaces, however, receive fifty charges in twelve hours, each charge containing six hundred-weight of roasted ore; the whole amounting to fifteen tons, which is produced from about eighteeen tons of the ore as it is raised from the mine.

In the smelting of iron cold air was formerly driven into the furnace to urge the fire to the highest degree of intensity. Mr. Neilson of Glasgow, however, in 1824, introduced the use of the *hot-blast*, which has since been employed with very great advantage. By this principle all the air before it is supplied to the furnace is heated by passing through tubes surrounding a fire, or in some cases by an arrangement in which the pipes conveying the air are made to derive their heat from the furnace itself. This hot air being driven into the centre of the incandescent mass effects the smelting of the ore more rapidly, since it does not produce the cooling which the ordinary *cold-blast* is said to do.

Dr. Clarke remarks—"The air supplied is intended, no doubt, and answers, to support the combustion; but this beneficial effect is, in the case of the cold blast, incidentally counteracted by the cooling power of six tons of

air an hour, or two cwt. a minute, which, when forced in at the ordinary temperature of the air, cannot be conceived otherwise than as a prodigious refrigeratory, passing through the hottest part of the furnace, and repressing its temperature."

The iron being smelted is allowed to run off into a channel made in sand. From this channel, called the *sow*, numerous side branches are led, called *pigs*, into which it is directed by the workmen; hence the term pig iron. From pig iron it is converted into bars of malleable iron by *refining*. In a proper furnace, the metal, mixed with coke, is kept in a state of fusion for about two hours, during which it parts with much of the carbon combined with it. It is then run into moulds. When cold the metal is withdrawn from these, broken into pieces, and thrown into the *puddling furnace*. The object of this is to deprive the iron more thoroughly of its carbon, which passes off as carbonic oxide, burning with a pale blue flame. The metal becomes thicker, as the process advances, until it assumes a sandy appearance, when the temperature is raised and the particles cohere. The workman now forms the mass, while hot, into balls, each weighing from 79 to 80 pounds: these are removed and subjected to several blows from a heavy hammer, and formed into what are called *blooms* (84).

The composition of iron varies greatly, and on this depends its quality. Bad pig iron contains carbon, silicum, and calcium. Towards the removal of these, or at least any excess, the attention of the iron-master is directed, and the delicate operation of puddling is intended to effect this object. The philosophy of the improvement of metal consists in the circumstance that a part of its impurities, which were originally in chemical combination, are converted into chemical admixtures. Iron, containing a small amount of carbon, silicon, or phosphorus, is always more hard and strong than pure iron. Pure iron is quite soft.

An examination of the celebrated Low Moor iron specimens, from 1 to 18 of the series, will show the peculiarities of each stage of the process we have been describing. The set of experiments made on the bar iron (from 20 to 27) show many peculiarities.

	Diameter, inches.	Stretched, in inches.	Strain when broken.
			Tons.
19. Rivet iron . .	$\frac{3}{4}$	4	$11\frac{1}{2}$
20. Bar or chain iron .	$\frac{7}{8}$	$4\frac{1}{8}$	15
21. Ditto .	1	$3\frac{3}{8}$	21
22. Ditto .	$1\frac{1}{8}$	$3\frac{3}{4}$	26
23. Ditto .	$1\frac{3}{8}$	$4\frac{1}{3}$	42
24. Ditto .	$1\frac{1}{2}$	$4\frac{1}{2}$	48
25. Ditto .	$1\frac{5}{8}$	5	59
26. Ditto .	$1\frac{3}{4}$	$4\frac{1}{8}$	66
27. Ditto .	$1\frac{1}{4}$	$10\frac{1}{2}$	34

The last bar was 4 feet 5 inches long, and the diameter was reduced by the strain to $\frac{3}{4}$ of an inch.

The above experiments were all made upon the iron when in a cold state.

The associated specimens show the different characters of the irons, as regards molecular constitution, ductility, malleability, &c.

In our examination of the Sheffield department, the manufacture of steel has been sufficiently described, to which the reader is referred.

The tools exhibited in connection with the Low Moor iron, the gun mounted upon one of Ferguson's patent gun-carriages, bomb-shells, shot, together with machines and engines, should be very carefully examined by all who are at all interested in learning something of the peculiarities of this important manufacture.

" Iron accommodates itself to all our wants, our desires, and even our caprices; it is equally serviceable to the arts, the sciences, to agriculture, and war. The same ore

furnishes the sword, the ploughshare, the scythe, the pruning-hook, the needle, the graver, the spring of a watch or of a carriage, the chisel, the chain, the anchor, the compass, the cannon, and the bomb. It is a medicine of much virtue, and the only metal friendly to the human frame."

The bloom of iron from Norway, which is exhibited (84) as possessing great toughness, owes its peculiarities chiefly to the modes of smelting adopted, which must be noticed when we come to the examination of the iron ores and irons produced on the Continent. The bars of iron, and the wire associated, serve to show the mode of drawing iron wire, which process has been already described. The origin of the term *bloom* is not easily ascertainable; it is, however of considerable antiquity, the most ancient iron-works in the country being called "*bloomeries*" and "*bloom-smithies*."

Tin-ware; Japanned-ware. (Exhibitors 60, 65, 270, 254, 160, 691.)—In connection with other examples of the hardware class will also be found numerous kinds of tin-ware. It has been already sufficiently described (page 51), that tin-plate is carefully manufactured sheet-iron, covered with a coating of tin by a process of immersion in the melted metal. Plannished tin-plate is such, as by being beaten with highly-polished steel hammers has a bright surface given to it, and of this kind the superior articles are always made. *Japanning* of tin-ware, or any other metal, consists in covering it with a varnish. The best varieties are treated in the following manner:—The article to be japanned is first brushed over with two or three coats of *seed-lac* varnish to form *the priming*. A varnish of the required colour is then laid on for the ground, and on this the design is painted. After which the whole is covered with transparent varnish, dried, and polished. Japanning must be carried on in warm apartments, and the metal is made hot before the varnish is applied, and it is dried in ovens prepared for the purpose. In some cases ordinary painting with lead colours is substituted for

japanning. For painting figures in Japan work *shell-lac* is usually employed; but sometimes, where the colours are delicate, mastic and fine copal are employed. It should be understood, that japanning consists in covering metal with a resinous varnish, which is coloured according to the taste of the manufacturer.

Enamelled Iron. (Exhibitors 1, 360, 555, 600, 657, 698, 701.)—The introduction of enamelled iron, which has been very recent, must be classed as an improvement by protecting the iron from corrosion; great cleanliness is secured, and all the advantages of using a glass or porcelain vessel obtained. In some case the enamel consists of a porcelanic mixture, which is applied in the state of "slip," and then exposed to a heat sufficient to insure fusion. This, in some cases, has been obtained by the extensive use of the salts of lead. The contraction and expansion of a clay body, however, being very different from that of iron, a true glass rendered opake or coloured by metallic oxides has been generally substituted. The cohesion of the glass to the iron is most perfect: the difference in the rates of expansion between them is very slight.

Metallography. (265.)—These inventions—for the process consists of two or more parts—are intended to produce results essentially distinct, but at the same time closely allied to each other.

The first consists of a system of machinery for planing, polishing, burnishing, and ornamenting in a peculiar style metals of every description as they come from the rollers, either in sheets, bars of any shape, or in tubes: these machines may also be employed to plane and polish sheets, bars, and tubes of wood, stone, glass—in short, any hard substance. The other result is a new style of ornamentation on the metals after they have been submitted to the previous process of planing and polishing. These ornaments are of such a nature that whilst, on the one hand, they produce the most brilliant effects, presenting bright

designs and inscriptions on a dark ground, or an imitation of wood, rivalling the most delicate workmanship, both in mosaic or marqueterie, they, on the other hand, are not affected by atmospheric influences, and may be subjected to any amount of labour.

Three machines are employed: the first for planing and ornamenting sheets of metal, the second for ornamenting bars of all shapes and tubes, and the third for polishing and burnishing sheets, bars, and tubes of metal, wood, &c.

In order to appreciate the importance of the first and second machines it will be necessary to remark, that metals, as received from the rolling machines, although they may have the required shape and form, are still far from having that finish which is desirable in manufactured articles. Then again being subjected by the workman to the action of the fire at a high temperature, they are invariably incrusted with a hard oxide, to remove which an immense amount of hand-labour is required before an even and bright surface can be obtained. The two machines above described are intended to accomplish that object.

These two machines are very simple. That for planing sheets of metal consists of a large cutting instrument fixed at a certain angle of inclination, above a sliding table: the distance of the said instrument from the bench or table may be regulated at will. A sheet of metal being fixed on the sliding table, the latter is set in motion, the metal is forced backwards and forwards, and is acted upon by the cutting instrument, and is thus perfectly planed.

The machine for planing bars and tubes consists principally of an instrument which, on account of its form and nature, cannot be described better than by calling it a "four-sided, or circular expansive plane." This instrument is composed for quadrangular bars of four cutting tools arranged round a centre, and for cylindrical bars and tubes, of a great number of cutting tools, say sixteen, placed like a radii of a circle in two rows, close to one

another, the instrument (being made so that by turning a conical screw-ring, which envelopes it, it expands or contracts at will. The remainder of the machine is nothing more than a common draw-bench. The bar or tube to be planed being placed by one end through the said instrument, is laid hold of on the other side by a pair of pincers; it is then pulled through the instrument itself, the instrument having previously been adjusted to the proper size, and when it has been drawn through the instrument a few times it will be found to be perfectly planed.

As regards the ornaments produced on sheets and bars of metals, nothing can be more simple than the instrument employed. For sheets of metals, instead of the plain cutting tool, one with teeth, of any required form or design, is substituted, so that, on drawing the sheet of metal under this new cutting tool, it comes out ruled; and if this be repeated in different directions, the result is a quadrangular or rhomboidal design, which may be varied *ad infinitum*, producing a pleasing effect. The same effects may be obtained on tubes and bars by means of the second machine, by substituting for the plain instrument above described, another, having some of its concentrical cutting tools shorter than others, so that it produces a dentated circumference.

Plates of metal thus ornamented are then coloured by being made one of the poles of a voltaic battery, and placed in a solution of some salts of copper and manganese. Oxides of these metals are precipitated, and the combination between them and the plate is exceedingly perfect. Another process consists in covering the metals to be ornamented with a resinous varnish of any colour or combination of colours required, and then employing types or engraved blocks of wood, previously wetted with essential oil to dissolve off the required portion of the coloured ground, leaving the pattern in the colour of the metal contrasted with that of the resin applied.

Stoves. (Exhibitors 88, 103, 106, 107, 185, 186, 238, 243,

247, 384, 386, 388, 389, 403, 407, 408, 481.)—Stoves of various kinds have been from time to time introduced, in all of which the principle sought to be established has been to produce the greatest amount of heat from the smallest consumption of fuel; and in this respect many of them have been eminently successful. Objections have been raised to the use of stoves in close rooms, from the circumstance that the air, coming in contact with heated iron, loses its moisture, and, becoming unnaturally dry, produces unpleasant effects upon the inmates. This has been sought to be avoided by placing vessels of water upon the top of the stove, that, by a constant evaporation, the necessary hygrometric condition might be restored.

It would appear, however, that something more than merely drying of the air takes place: a peculiar smell always accompanies air which has passed over heated iron. On this subject the following remarks are to the point:—

"As cast iron always contains, beside the metal itself, more or less carbon, sulphur, phosphorus, or even arsenic, it is possible that the smell of air passed over it in an incandescent state may be owing to some of these impregnations; for a quantity of noxious effluvia, inappreciably small, is capable of affecting not only the olfactory nerves, but the pulmonary organs."

There are, however, other causes at work, producing consequences to which may probably be referred many of the peculiarities which belong to air warmed by contact with hot iron. At least experiment appears to show that the electric condition of the air is materially changed by the action of a heated metal surface upon it. It is therefore desirable, in all stoves, that means should be provided to prevent any undue warming of the outer casing, and that ventilation be particularly attended to. When fuel is burning slowly, so as not to heat the iron surface above 300° Fahr., the carbonic acid which is formed during combustion sinks into the ash-pit and floats out into the

apartment. Hence it is that many of the exhibitors claim the production of ventilating stoves, and many of them show most ingenious arrangements for producing the circulation of pure air.

The adjustments of Arnott's stoves (398) exhibit some very nice arrangements by which the quantity of air supplied to the fire is regulated. A float on the surface of mercury is connected with the valve through which air is admitted to the fire, so that, as the mercury expands by the increasing heat of the stove, it closes the valve, and, by checking the air, prevents the combustion from going on so rapidly. Amongst the ventilating apparatus exhibited, Dr. Arnott's is the most effective (636). It consists essentially merely of a balanced flap protecting an aperture into the shaft of a chimney. The rapid ascent of the heated current of air up the chimney draws a constant supply of air from the room at that part of an apartment near the ceiling, where heated and vitiated air is most abundantly present. The valve is adjusted by its balance, so that the entrance of smoke is prevented by its closure.

Several of the exhibitors show arrangements by which air is brought from without the building and discharged warm into it. The pyro-pneumatic stove (107) is, from its peculiar construction, worthy of close inspection. The whole of the interior is made of fire-clay, moulded in various pieces, and so arranged that passages or air-ways pass through them. The stove may, therefore, be regarded as formed entirely of fire-brick, the exterior iron casing having little to do with the principle. An open fire warms the casing of fire-brick, and, as the passages are all connected with a pipe leading to the external air, that which they contain, being warmed, rises into the apartments, and are supplied with fresh air from without. The fire is connected with the ordinary chimney, and the products of combustion are carried off by that channel, the necessary oxygen being freely obtained from the air which flows into the apartment, warmed, through open-

ings in the top of the exterior case. By this arrangement a more effective system of ventilation is established, the deteriorated air passing off by the chimney, and a constant supply of fresh air, of a genial warmth, unceasingly flowing into the room, in such a manner that no sensible draught is experienced.

It is quite impossible to deal with the peculiarities of each stove exhibited: the main principles of all are indicated, the detailed arrangements are left for the examination of the visiters. The forms of some now exhibited will be found to be improvements upon those ordinarily employed: many display high artistic skill in the design and ornament. The cottage stove, in fire-clay (107), appears to be exceedingly well adapted for the purposes for which it is intended.

Stove Grates. (Exhibitors 97, 102, 106, 107, 186, 237, 247, 384, 405, 407, 410, 686.)—The principles of the ordinary fire-place are familiar to all, and the only alteration which will be found consists in setting it rather lower than usual, In many of the drawing-room grates the principle of steel reflecting surfaces are largely introduced, and in some the circular form, with the fire-place in the centre, insures the total radiation of all the heat into the apartment. Beyond those points, and the connection of circular metal bars projecting into the apartment, which warm the air by convection, there is no particular novelty in the way of construction.

New designs are numerous, and many of them of exceeding elegance. Any particular example is avoided, leaving the selection to the taste of the observer. The castings on many are remarkably good, and the colour of the metal, as we have already remarked, shows a considerable improvement in our manufacture. The combinations of marble, alabaster, and metals are often effective, and in many cases tiles have been introduced with much effect.

Kitchen Ranges and Apparatus. (Exhibitors 93, 98, 244,

370, 381, 393, 606.)—A large number of the articles which may be classed under this group, display a considerable amount of ingenuity. The great point to be attained in all of them is the economy of heat. Whether an open or a closed fire is employed, the flues and metal connections should be so arranged that the heat is very rapidly and with tolerable equality distributed over the whole space. This appears to be effected admirably in many of the kitchen-ranges exhibited.

Gas Stoves. (Exhibitors 236, 241, 248, 389, 431, 433, 482, 643.)—The use of gas-stoves has very much increased within a few years: prejudices which existed are dying out, and difficulties have been overcome. Ordinary coal-gas is a carburetted hydrogen, that is, hydrogen gas fully saturated with carbon vapour; and if a sufficient supply of oxygen is secured during combustion, the whole is converted into carbonic acid and water, giving out during the chemical changes, equivalents of heat corresponding exactly to the intensity of chemical action. These gas-stoves are recommended for warming large or small buildings, heating baths or boilers, builders' glue-pots, chemists' stills and spatulas, bookbinders' tools and arming-presses; hatters', laundresses', and tailors' irons; drying cigars; broiling chops, steaks, and kidneys; baking bread or pastry, roasting, stewing, frying, steaming, toasting bread, roasting coffee, and other useful purposes, many of which may be accomplished with cleanliness and very little trouble in any building, without a chimney.

If the supply of atmospheric air is sufficient, all the carbon is converted into carbonic acid, and no smoke escapes; but still some plan of removing the carbonic acid should always be secured, or injurious effects may follow. One exhibitor shows what he calls "atmopyre hoods" (241), in connection with his gas apparatus: they are made of porcelain; the gas is introduced into the interior, and escapes through small perforations in the sides, 1-50th of an inch in diameter, and when ignited,

burns with a pale blue flame, and emitting little or no light; in a few minutes the mass becomes red-hot.

By covering a cylinder of copper with wire gauze, and discharging coal-gas into the lower part so as to cause it to unite with a certain volume of atmospheric air, a gaseous mixture is produced, which burns over the wire gauze with a blue lambent flame. The perforated hoods of porcelain, in the invention described, are the representatives of the chemists' wire gauze, with the advantage, for heating purposes, that they retain a portion of the heat developed by the combustion of the mixture of coal-gas and atmospheric air.

The advantages to be derived from the use of gas are many. The required heat can be obtained at any moment, and most uniformly maintained as long as it is required, and immediately extinguished when no longer necessary. In chemical laboratories it is now almost universally employed; and, no doubt, in a few years it will be as commonly used in domestic establishments.

Gas-burners. (Exhibitors 101, 431, 438, 445.)—To produce the greatest degree of illumination, certain conditions are necessary. The gas should be saturated with carbon: this is effected by passing it through naphtha, from which it takes up a considerable quantity; the result being the production of a pure amber light, provided the quantity of oxygen supplied and circulation in the chimney are carefully adjusted. The gas-burners exhibited are intended to effect this adjustment: their relative merits are to be established by experiment.

Lamps. (Exhibitors 103, 132, 323, 350, 442, 446, 451, 452, 455, 458, 459, 463, 464, 472, 474, 477, 487, 534, 638, 644, 645, 697, 798.)—Under the names of carcel, diamond, condensing lamps, &c., a very considerable variety in the means for burning oil are exhibited. The great quality of a lamp is to keep the wick sufficiently supplied with oil to maintain a good flame, without the flowing over of any of the combustible material. Many of the examples are of

great ingenuity, and the arrangements, as regards form, &c., in many cases, are exceedingly elegant.

Ice-Safes; Refrigerators. (Exhibitors 600, 601.)—The Wenham Lake Ice Company have exhibited their arrangements for preserving ice. The circumstance of the trade in ice is not a little remarkable from its novelty and the extent to which it is now carried on; this natural product being sent to almost every part of the world.

There are some facts connected with the physical conditions of frozen water which are most remarkable. When perfectly still water freezes, the ice is always full of air-bubbles: this arises from the circumstance that water in freezing rejects everything which it may hold in solution, —air—colouring-matter—saline substances—or acids; and being at rest these matters become involved with the frozen particles. But if the water while freezing is slightly agitated, all these matters accumulate either in the centre of the mass, or, as in the case of air, escape, leaving the ice perfectly pure. The ice of the Wenham Lake is in this condition—the water produced by thawing it, not even containing air. It might be incidentally mentioned here, that the water thus obtained free from air does not obey the same law as ordinary water in relation to heat. Ordinary water, at the mean temperature and pressure of the atmosphere, boils at 212° Fahr. But that which is deprived of air may be heated considerably above that point, without indicating the least sign of ebullition; and when it eventually commences, it is rather with the violence of an explosion than as ordinary boiling.

In constructing ice-safes, the points to be attended to are—the formation of an envelope, or series of envelopes, which are very imperfect conductors of heat, so that the interior ice may not be affected by the temperature of the external air. Ice wrapped in flannel, for example, continues for a long time, even in a warm room, without thawing—the heat passes so slowly through that material;

on which account it forms the warmest kinds of clothing, not allowing of the escape of that animal heat which results from vital action. Ice-safes are so formed that cases of air surround the frozen material, air conducting heat but very slowly.

In refrigerators the artificial cold is produced by the liquefaction of certain chemical compounds. The heat required to produce liquefaction is taken from the body, which is submitted to the cooling process; and hence by this means we are enabled to produce almost any degree of cold. Certain salts—these may be largely varied—are put together in the refrigerator: by their action on each other liquefaction ensues, and the water or cream placed in it parts with that caloric which kept it fluid, to produce fluidity in the freezing mixture, and it becomes solid.

The ordinary salts of soda, potash, and lime, with diluted acids, are usually employed; but where it is desired to produce a very intense cold, Thilorier's bath of solid carbonic acid and ether is generally employed; with this many of the gases have been condensed into solids and fluids.

Fire-proof Safes. (Exhibitors 280, 356, 506, 507, 509, 678, 646, 642.)—In all cases fire-proof safes consist of two cases, one between the other, the opening between the two being filled in with some non-conducting material, so that the inner lining of the case may never become incandescent. This is in some instances effected by the interposition of clays, in others of chemical compounds, and in some a stream of water is made to flow through the chambers of the case whenever it is exposed to the action of fire.

Anhydrohepseterion. (500.)—This may be classed among the little ingenuities of which there are many examples in the class. It is an arrangement by which the water contained in the potato is made to cook that vegetable. The potatoes being placed upon a false bottom, heat is applied, steam is generated, and this being confined by a secure cover, the whole is readily and perfectly dressed.

The same exhibitor has several other very ingenious contrivances for various purposes; amongst others we may name the *Pedestal Wash-stand*, the object of which is to produce an ornamental exterior, by which a useful article may be fitted for any apartment.

Miscellaneous.—In this extensive class will be found a number of articles which cannot be grouped under any general head, amongst these may be named *stable stalls, and enamelled mangers* (1); numerous specimens of ornamental iron castings, in the shape of carriage gates and ornamental iron chairs; *horse-shoes*, constructed of various shapes, for the purpose of insuring greater freedom and ease to the foot of the horse; *letter-copying machines* (18, 19, 20, 397); *perforated brasses and woven wire blinds*, much of the perforated brass displaying extraordinary fineness of work—one specimen (29) showing fourteen thousand four hundred square holes to the square inch; forges; bellows; chimney-pots; bell-pulls; door-handles; and all the numerous utensils employed for culinary purposes.

Gas-meters, of the dry and wet kinds, will be found in this class, and a large dry gas-meter, fixed for convenience in Class I., by which all the gas supplied to the building is measured, should be inspected by those who desire to make themselves acquainted with the peculiarities of these arrangements.

Washing, Wringing, and Mangling Machines (Exhibitors 538, 643, 546, 548, 535), present many ingenious peculiarities. They are variously constructed. The use of them may be understood from the following description, which accompanies one of the models, which, with some slight variations, applies equally to all:—

The washing machine is used as follows: the clothes are to be steeped the night before, with as much hot water (having a little soap and soda dissolved in it) as will cover them. Before commencing the washing, as many of the clothes are to be taken out as will allow the ranger to operate freely, and boiling water put in. It will be seen,

on inspection, that the clothes, on being struck by the ranger against the side of the tub, take a triangular form, having the acute point next the bottom, so that, after being pressed against the side, they turn in falling, and a continual revolving motion of the clothes is kept up while the operation is going on. When thoroughly cleansed, the ranger and the clothes are taken out of the tub, and the wringer put in use to press out the water. The clothes being put in at the slit of the wringing-bag, and equally distributed through it, the crank is to be turned until the water is pressed out, which is so efficiently done that a very short time's exposure in a dry atmosphere fits them for the mangle.

The mangling is accomplished by unrolling the mangling cloth to the length of the articles to be mangled, then, the clothes being laid on and the handle reversed, they are taken in between the centre roller and the mangling cloth; after a few turns, reverse the movement of the handle, when the clothes will appear on the feeding-bench ready for folding.

Pigeon-traps, rat-traps, fumigating apparatus, gauffering-machines, house alarums, meat-preservers, &c., sufficiently show, with the articles already named under this miscellaneous head, the great variety of ingenious articles to be discovered under the general classification of Hardware.

Urns, Vases, &c. (401.)—These specimens of hammered copper are very remarkable, as proving, under proper management, the ductile character of this metal. The progress of raising these vessels with the hammer is shown. The metal has to be several times annealed during the operation.

Within the Class will be found many examples of electro-plating; but as this process belongs more particularly to Class XXIII., our notice of the peculiarities of the process is reserved for that section.

THE MEDIÆVAL COURT

(Exhibitors 529, 530, 531, 532, 533, 534, 535, 536) is directly in front of the Sculpture Room, and may be entered either from the Main Avenue or the Corridor.

In the Catalogue it has been placed at the end of Class XXVI., to which class the numbers have reference; but its position in the Building, and its metal and mineral manufacture, appear to associate it with the Classes I. and XXII.

Its peculiarities consist in the revival of the ancient and middle age style of sacred and domestic furniture and decoration. The visiter will find how much the ancient workers in metal, stone, and timber, could effect, by referring to what is here shown, and which, in the majority of cases, are careful reproductions from celebrated models which now exist, and which have been copied and the wanting details supplied through the instrumentality of A. W. Pugin, Esq. The metal-work by Messrs. Hardman, consisting of altar fittings, chandeliers, corunnas, brackets, &c. in brass, the railings for a stove, and a light to be used out of doors, formed of iron, and peculiar from the complicated and elaborate character of its ornament, is worthy of attention by those who are interested in "Curiosities of Manufacture," and exhibiting the capabilities of modern workers to accomplish, when there is the will, those marvels, which those wedded to hoar antiquity deemed them incapable of. One feature will be observed worthy of attention, the reintroduction of beaten work, viz., raising thin plates of metal by means of the hammer; a mode which admits of the production of the greatest versatility of form, but which had been exchanged for the stamp and die, with the necessarily conventional forms dependent upon the necessity of attending to the "lift" or removal of the "force." The lamps attached to the hanging-beam, suspended in front of the altar, the salvers, flagons, and plate, in front of the oak "buffet," are all raised by the process described. It is satisfactory to remark the successful revival of the

ancient art which flourished with so much success at "Limoge," viz., enamel, which here lends its aid to bring out with greater splendour the "the patterns of bright gold," which show themselves with so much and excellent effect, in pix, expositorium, ciborium, &c., &c. In personal decoration, a set of jewels, mounted after the olden style, minus the frittered ornamentation of to-day, are evidences good and true of the ancient appreciation of the value of form, apart from that complication which interferes with the brilliancy, by the reduction of surface, upon which the light plays its most fantastic vagaries.

The ornamentation of a variety of the smaller ecclesiastical decorative pieces, with rich mountings of gold and silver, precious stones being scattered over the surfaces of cups and vases in profusion, has the most pleasing effect. There are other specimens of altar ornaments, of immense size, which also exhibit beauty of design and admirable finish: amongst these may be noticed six huge pillars in brass surrounding an altar, with angelic figures at the top. Brass chandeliers, brass stands and tables, images and candlesticks, candelabra, lecterns, &c., and a number of prayer-books, in various bindings, will be much admired. The silver-gilt chalices, gilt flagons, altar crosses, &c., will also command attention. The rich priestly vestments are good examples of that kind of embroidery and ornamentation which are employed on the robes of ecclesiastics. The furniture of Crace, in combination with the works of Hardman and Myers, is truly effective, and especially is this the case in the font of stone-work in the centre of the court, the panellings of which are decorated with *bas-reliefs* of an admirable character, while above the whole is a canopy of oak delicately carved. This is a fair sample of the excellence of this class of production. The principal portion of the furniture is placed on the eastern side of the Court; and, as a fine specimen, we direct attention to the carved *bas-reliefs* of Christ in the Garden, his carrying the Cross, and the Crucifixion. The tomb or

Dr. Walsh, with its rare escutcheons of encaustic tiles, is a fine example of imitative mediæval art. The Caen stone-carvings in the font, and the altar tomb, are characteristic revivals of the ancient style of stone-cuttings of the best sculptors in the heyday of Christian art.

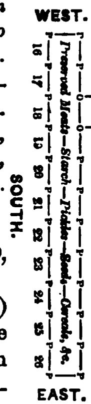
On the side of the compartment, looking towards the Nave, will be observed the contributions in Stained Glass; exhibiting considerable brilliancy and harmony of colour—

> "Innumerable of stains and splendid dyes
> As are the tiger-moth's deep-damasked wings;
> And in the midst, 'mong thousand heraldries,
> And twilight saints and dim emblazonings,
> A shielded scutcheon, blush'd with blood of queens and kings."

The end which is sought after in these, is not to produce a picture (as in the great window in the Nave, decorated with scenes from Dante), but simply to produce a medium through which the light should pass unobstructed, turning into purple and gold every detail which is cut with chisel, carved with gouge, or elaborated by worker in metal, or the produce of the loom, which decorates the interior of the Building, in whose mullioned windows the stained glass is inserted. The curious variety of Art Manufactures which crowd this Court, whether in the form of carved oaken balustrade, "buffet," bookcase, or rood-screen—paper-hangings, resplendent in their contrast of rich gilding with the deep blues and crimsons of their ground, textile hangings and cloths for altars, revealing the produce of the looms of continental celebrity, or Minton's tiles, excellent copies of the old encaustic varieties—will be found to be objects of much interest, particularly when viewed as the revival of that style of church decoration, which sought to give expression by symbolic representations to the pervading spirit of piety—under the influence of which arose those splendid fanes, which must for ever exert a solemnly soothing influence upon the mind of every one who walks within the shadow of their gracefully arched aisles.

Class III.—Animal and Vegetable Substances used as Food.

Situation of Class 3.—*In the Southern Gallery, between the Section devoted to Chemicals, and that appropriated to Naval Architecture. Between Pillars* O. *and* P., 16 *and* 26.



Position of Groups (Numbers referring to Pillars).—Preserved Meats, 16 to 17.—Tea, Coffee, Tobacco, 17 to 18.—Starch, Mustard, Salt, 19 to 20.—Preserves and Pickles, 21.—Seeds, 22 to 23.—Grass, Grain, &c., 23 to 24.—Peas, Peppers, 25.—Woods, Vegetable Produce of Scotland, 26.

British Agricultural Produce.

Wheat. (Exhibitors 70, 71, 73, 74, 75, 79, 82, 88, 90, 91, 92, 93, 94, 100, 104, 105, 106, 114.)

Wheat Flour. (Exhibitors 150, 152, 159, 160, 162.)

In the absence of authentic official data, the value of the agricultural produce of the United Kingdom is mere matter of conjecture. In Weld's "Statistical Companion for 1850," that of England and Wales is estimated at 69,150,000*l.*, taking the average yield of wheat at 26 bushels, barley and rye at 32 bushels, oats 36 bushels, beans 36 bushels per acre; and taking the average price of wheat at 50*s.*, barley and rye 30*s.*, oats 25*s.*, and beans 35*s.* the quarter; allowing also 5*l.* 5*s.* as the value per acre of root crops, turnips, potatoes, &c., and calling the produce of hops and gardens 2,250,000*l.* per annum.

By the same authority the arable land of England and Wales is stated at 11,053,370 acres; the meadow and pasture at 17,605,630 acres; the arable land of the United Kingdom at 19,135,990 acres; the meadow and pasture at 37,386,980 acres, making a total of 56,522,970 acres of cultivated land. At this rate the value of the produce of the United Kingdom would be about 140,000,000*l.*

In Spackman's "Statistical Tables for 1843" the average produce of England and Wales is estimated thus:—Wheat, 21; barley, 32¼; oats, 35½; rye, 23¾; peas, 23; beans, 25¾; potatoes, 280—bushels per acre. At the average prices of that period, the value of this produce was supposed to amount to 6*l.* the acre; and allowing the cultivated land of the United Kingdom to be 46,522,970 acres (about ten millions of acres less than Weld's statement), he reckons the value of its produce at 279,137,820*l.*, but thinks that recent improvements might have raised it to 300,000,000*l.*

If we money the arable land of Weld's statement by 5*l.*, and the meadow and pasture by 2*l.*, we shall have 170,000,000*l.* as the value of the annual produce of the United Kingdom. Again, the rental of lands in Great Britain, assessed to the income-tax at present, exceeds 37,000,000*l.*; which, if equal to one-fourth of the gross produce, would make the latter 148,000,000*l.*, exclusive of that of Ireland, where there is no income-tax, but where the rental was estimated at 9,000,000*l.*, before the extensive and repeated failures of the potato, which have deranged so completely the agriculture of that country, and the social system based on it.

Thus vague is all the information attainable on this important subject!

The division of agricultural produce into primary crops, or those applied directly as human food, and secondary, fallow, or forage crops, destined for conversion into animal produce for the formation of manure, and the cleaning and pulverising of the soil, may be adopted as a general classification, although not strictly correct. It indicates one principal cause of the great advances made by British agriculture during the last seventy or eighty years—the substitution of these alternating grain and forage crops for the old system of three or more corn crops, followed by a bare fallow, or by rest under natural pasture. The modern system admits of the maintenance of large quantities of live-stock on arable land; and, by the attention

paid to the improvement of the breeds of domestic animals, these have greatly increased in average weight, and reach maturity at an earlier age than formerly. It is chiefly through these improvements (combined, however, with competition among the agricultural class, for the occupation of land), that the general rental of land has increased since 1815, in the face of a great and continued decline of prices. This increase is proved by a comparison of the income-tax returns for 1815 and 1842. At the former period wheat had averaged for the preceding five years 102*s.* 7*d.* the quarter, and the rental of land was assessed at 32,502,000*l.*, the lowest price at which wheat could be grown without loss being then supposed to be 80*s.* the quarter. In 1842, when wheat had averaged, for five years, no more than 64*s.* 7*d.*, and the remunerating price was deemed 56*s.*, the rental of lands amounted, according to the same returns, to 37,794,000*l.* This was exclusive of the rental of Ireland.

It is to the general diffusion of this improved farming, which has made greater progress in some districts than in others, and to the application of chemical science to agriculture, from which we have already reaped some valuable results, that we must look for such an increase of home-grown produce as shall meet the demands of our rapidly increasing population. From the extensive importations of foreign and colonial produce which have taken place since 1846, and from the absence of all accumulation of food, either of foreign or home growth, it is evident that the consuming powers of the British people are greatly in advance of the producing powers of British agriculture.

In examining the agricultural produce of Britain, as represented in the Exhibition, it will be advantageous to commence with the Collection of the Vegetable Produce of Scotland, exhibited by Messrs. Lawson & Son, of Edinburgh, not only because of its completeness and systematic arrangement, but because of the copious and elaborate Synopsis by which it is illustrated.

To the divisions of this synopsis may be referred the insulated specimens of agricultural produce sent by other Exhibitors from various parts of England and Ireland, which, being close at hand, may be conveniently studied in connection with it.

This collection is arranged under six heads—

1. Plants cultivated for their seeds and straw, such as the cereals and leguminous plants;

2. Those cultivated for herbage and forage, such as the grasses and clovers;

3. Those cultivated chiefly for their roots, as potatoes, turnips, &c.

4. Vegetable products, whether cultivated or of spontaneous growth, used in the arts and manufactures, either for their fibre, as flax and hemp; for oil, as flax and rape; for their colouring-matter, as woad, or for miscellaneous purposes, as the fuller's teazle.

5. Plants, whether wild or cultivated, used in medicine.

6. Plants used for timber, including, besides the indigenous trees, those which have been naturalised in woods and plantations.

Of the first division, plants cultivated for their seeds and straw, the Lawson collection contains more than 400 specimens. Those most generally cultivated in Scotland are exhibited in sheaves or bundles; those which have only been cultivated experimentally are represented by small dried specimens, each with the name attached, like those in a herbarium, with numbers referring to the Synopsis, in which a full description of them is given. Each is accompanied by a specimen of the seed, in sufficient quantity to be produced for sale in a sample market. The various kinds of meal, prepared from those in most general use, are exhibited in connection with the kind of grain from which they are derived.

The first and most important section consists of the cereals; among these, wheat (*Triticum*) claims the first notice. Of the seven groups, whether species or varieties, of

which it is composed, the most important is *Triticum sativum*. To this belong almost all those in general cultivation, whether distinguished by the colour of the grain, as white and red wheat; by a short and compact ear, as Piper's Thickset; by an ear of medium length, as the Chidham; or by a long, loose, and narrow ear, as the Talavera. In this group the Lawson Synopsis enumerates 142 varieties, out of which 24 may be seen exhibited in sheaves, as generally cultivated in Scotland. Many of these are the common varieties of England, from which they have been introduced into Scotland. For their names, qualities, history, and the names of the individuals by whom they were discovered, or raised, or introduced into Britain, the Lawson Synopsis, which gives them in ample detail, should be consulted.

Next to *Triticum sativum* rank, in these islands, the varieties of *Triticum turgidum*, or bearded wheat, distinguished by their long awns, like those of barley, and the strength of their straw, which renders them well adapted to land on which finer-strawed wheat is apt to be lodged. From their lateness they are not suited to the northern portion of Britain, and from their coarseness they are not in very high general estimation in any part of it. The range of *Triticum durum*, or hard wheat, is along the shores of the Mediterranean and Levant. It yields the flour from which macaroni is made, and is frequently imported into the London market, where, from its hardness, it is disliked by the millers. This, and *Triticum Polonicum*, called Polish rye, Grecian wheat, wheat of Cairo, and Mogadore wheat, are wholly unsuited to our climate. *Triticum spelta*, or spelt wheat, might be grown here; but though extensively cultivated in Germany and other parts of the Continent, it has not proved, on experiment, sufficiently profitable to establish itself in this country. It is distinguished by its long, slender, and erect ears, thin spikelet, and coarse adhesive chaff.

Among the different kinds of meal prepared from wheat

will be seen, besides fine, second, and coarse, flour with pollard and bran, of different degrees of fineness, a meal called semola, consisting of the gluten of wheat, separated from the starch.

The specimens of wheat contributed by other exhibitors are—Eggshell white wheat, grown in Suffolk, 64 lbs. per bushel. Very large and full-eared white Cornish wheat, in the straw; and from the Truro Local Committee, Cornish red wheat, grown in the neighbourhood of Penzance, recommended as suited to the high and exposed lands of Cornwall, and much approved by the millers for the quality of its flour; also specimens of white wheat, specially recommended for such situations; together with a sheaf of white wheat from Truro, named the Giant-straw Wheat. Kessingland wheat, grown on a light soil, at Hengrave, Suffolk. Specimens of wheat produced by hybridisation, and of the Hopetoun and Piper's Thickset, from which the hybrids were obtained. Specimens of ears of wheat, artificially hybridised, with the parent varieties, in each case, from which the hybrids were derived, showing, in most instances, improved colour, luxuriance of ear, or strength of straw, and, in a few, deterioration. A variety of rivet, or bearded wheat, named Defiance, from Moat, Essex, stated to be recommended by the principal agriculturists of the neighbourhood as being very prolific, and of good quality. A new variety of white wheat, weighing 64¼ lbs. per bushel; sample described as taken from the bulk, and neither screened nor hand-picked. Red-straw white Essex wheat, Nursery red lammas, red wheat, and Talavera wheat, grown in Wiltshire, and Collyweston white wheat. Hoary white wheat, produce over five quarters to the acre, and white trump wheat, grown on a poor soil, weight 67 lbs. per bushel; with improved white wheat, 66 lbs. per bushel, and white Chidham wheat, Footscray, Kent, described as weighing 74 lbs. per bushel. We also find specimens of ears of wheat, grown by spade husbandry and dibbling, and some Chidham wheat, grown on the Royal farms at

Windsor Park, weight 64 lbs. per bushel; soil retentive yellow clay. Lastly we have white wheat, from Nairnshire, first crop on recently improved land not worth previously more than 1*s*. per Imperial acre; produce about five quarters, weight 65 lbs., dressing 3 cwt. of Peruvian guano.

The specimens of wheat above enumerated consist in general of a bushel, and frequently of larger quantities. They are followed by samples of wheat flour.

Rye (*Secale*). (Exhibitors 104, 105, 114, 115.)—This, the prevailing grain of the north temperate zone, grown extensively in the south of Sweden, Norway, and Denmark, and all the lands bordering the Baltic, in the north of Germany, and in Siberia, was once much cultivated on the poor soils of England for the food of man. Under an improved agriculture, it has been supplanted by wheat. Before the late Earl of Leicester commenced his improvements in Norfolk, the Holkham district was a rye country; the peasantry lived on rye bread, and the small quantity of wheat consumed in the houses of the gentry was imported. Now the food of the rural labourers is wheaten bread; the land, which formerly produced only scanty crops of rye, averages four quarters of wheat to the acre, the rent has advanced to 20*s*. and 25*s*. the acre, from less than 3*s*., and the district exports wheat largely to London and the north of England. So slow, however, is the march of improvement in agriculture, compared with what it might be, that nine years elapsed after Lord Leicester had proved that the Holkham soil was capable of growing wheat, before he could induce a single tenant-farmer to follow his example.

Rye straw is still valued by the brickmakers as a covering for their bricks while in the hacks, on account of its stiffness and durability; and it was in demand for bonnet-making before the alteration of the tariff, which admitted foreign straw-plait free of duty; but rye is now chiefly cultivated in Britain as early green food for sheep and horses, either alone or mixed with vetches. A variety recently introduced under the name of St. John's-day, or

Midsummer rye, is later in running to ear and ripening than the common sort, producing longer straw, larger ears, and more root foliage. Messrs. Lawson describe its cultivation as rapidly extending in Scotland for the first crop on reclaimed moorland. So great a stranger has rye become, as a corn crop, to British farming, that there is scarcely a specimen of it to be seen in the Exhibition, except in the two collections named.

Barley (*Hordeum*). (Exhibitors 70, 71, 73, 76, 99, 102, 104, 110, 112.)—Of the four species, or principal varieties, *Hordeum vulgare*, bere or bigg, and *H. distichon*, two-rowed or long-eared barley, are the most important. *H. hexastichon*, or six-rowed barley, and *H. zeocriton*, or sprat-barley, being scarcely cultivated, or worthy of cultivation, in these islands. *H. vulgare* is chiefly grown in Scotland; *H. distichon* in England. The Lawson Synopsis enumerates 12 varieties of the former, and 26 of the latter. The favourite malting barley in England is the Chevalier, introduced by Dr. Chevalier, of Aspall, about 20 years ago, distinguished for its round and plump grain and superior yield. It is also largely grown in Scotland, where, however, its sample is in general inferior to that of English growth. Specimens may be seen in the Lawson Collection, and also with other varieties of barley exhibited by the various contributors. These consist of the following:—(70.) Chevalier barley, 56 lbs. per bushel, and the malt made from it, at Ipswich, 42½ lbs. (71.) Black barley, in the collection of the Truro Local Committee. (73.) Chevalier barley, grown at Hengrave, Suffolk. (76.) Barley grown in the county of Wexford, Ireland. (99.) Black barley, from Ballymore, county of Roscommon, Ireland, grown from African seeds. (102.) English barley (two-rowed), grown near Pitlochry, Perthshire, 600 feet above the sea. (104.) Barley in the collection of Messrs. Gibbs & Co. (110.) Barley, after turnips, in a five-course rotation, with the ordinary farm-yard manure, Banchory, Scotland. (112.) Skinless Chevalier barley, a new variety,

from Reading. Specimens of barley-meal and barley-bread may be seen in the Lawson Collection; also specimens of pot or pearl barley, coarse and fine.

Malt. (Exhibitors 70, 76, 77, 78, 107, and Class 2, No. 91.) —(70.) Malt from Chevalier barley, made at Ipswich, 42½ lbs. per bushel. (76.) Malt from barley grown in the County of Wexford. (77.) White, amber, and brown malt, made at Bishop's Stortford, Herts. (78.) Pale malt from Chevalier barley. (104.) Barley in the collection of Messrs. Gibbs & Co. (107.) Malt, manufactured at Antingham, Norfolk, weighing 43, 43½, and 44 lbs. per bushel. (148.) Patent crystallized malt, described as being converted into sugar.

In the Chemical Department (Class II., No. 91) is exhibited an Imperial gallon of porter and ale, of medium strength, with the respective quantities of malt and hops, used in the production of each. We have, 1st. The barley, as prepared for malting; 2ndly. The same, sprouted, when the development of the diastase is at its maximum; 3rdly. The same, dried in the kiln, as malt, with a portion charred or roasted, for the colouring of porter.

The process of malting converts the starch of the grain into sugar in precisely the same manner as this takes place in natural germination. The grain being moistened, is placed on the malting-floors and kept at a certain temperature—germination begins, the starch absorbs oxygen, and is converted into sugar—which is evidenced by the sweetness of the malt as compared with the barley: at this stage the process is stopped, and the malt dried for use.

Oats (*Avena*). (Exhibitors 85, 86, 104, 105, 107, 115, 153, 159, 161, 162, 163.)—The range of cultivation of this grain extends even to the Arctic Circle. It forms the staple cereal product of Scotland. Of the 2,400,000 acres of arable land in that country, it is estimated that 220,000 are applied to the culture of wheat, 280,000 to barley, and 1,275,000 to oats. Oats also enter largely into the food of the peasantry of Wales, and of the English counties north

of Trent. Of the seven species, or principal varieties of oats, those most generally cultivated in Britain are the *Avena sativa*, or common oat; *Avena orientalis*, or Tartarian oat, distinguished by the panicle being more contracted, and confined to one side, very prolific, and suited to high situations and inferior soils. Out of the 60 subvarieties of *Avena* in the Lawson Collection, not above 30 are grown in Scotland, and of those only 12 are in general cultivation. *Avena brevis*, or short oat, extensively grown in the mountainous districts of France, is held in no estimation in Britain. The *Avena nuda*, or naked oat, has the appearance of an oat from which the hull has been removed. Though many experiments have been made with it in England during the last two centuries, it has not established itself, probably from its liability to shed when ripe; although it is very prolific, and grows well on poor soils. *Avena sterilis*, closely allied to *Avena fatua*, or common wild oat, is occasionally cultivated in gardens as a curiosity, under the name of Fly, or Animated, oat, from the property the grain has of acquiring a creeping motion, when the long awns are acted upon alternately by heat and moisture. Both this and the seed of *Avena fatua* are sometimes, from their resemblance to a winged insect, used as bait in salmon-fishing.

The manufactured produce from the oat is exhibited in its varied forms, of oatmeal of ordinary quality, small, very small, very fine and high-dried oatmeal, oatmeal bread, and groats; together with the seeds and hulls of oats, used as cattle food, and from which sowens is prepared, by steeping them in water. The specimens of oats and their manufactured produce are not numerous.

Maize, or Indian Corn (*Zea, Mays*). (Exhibitors 71, 98, 105). —A native of South America, and the only grain cultivated there at the time of its discovery. Various attempts have been made at different times to cultivate it in this country, but without success. It is only the dwarf varieties which will ripen here, and that only in favourable seasons. These

attempts have been renewed of late, since the potato failure has rendered necessary such large importations of maize for the support of the Irish peasantry.

Specimens may be seen in the Lawson and Cornish Collections; also at 98, forty-days' maize, from the Pyrenees. If maize shall ever establish itself among British farm produce, it will only be for consumption in a green state as a forage crop.

Canary grass (*Phalaris canariensis*). (105.)—Is grown in considerable quantities in the south of England, particularly Kent, chiefly as food for cage-birds; at least the growers know of no other purpose to which it is applied. In the Canary Isles it is ground into flour, and produces a nutritious bread.

Leguminous Plants.—Beans (*Faba vulgaris*). (Exhibitors 73, 83, 92, 94, 107.)—These are divided, in the Lawson Synopsis, which contains 25 varieties, into three sections:—1. The common field varieties; 2. Varieties suited either to the field or garden; and 3. Garden varieties. Besides samples of the seed and specimens of the dried plant, that collection exhibits models in wax of the pods of each variety. In other parts of the Exhibition specimens of beans are not numerous. They consist of (73) tick beans, with white eyes, grown at Hengrave, Suffolk; (92) golden pod-beans; (94) prolific beans, from near Newbury, weight 70 lbs. per bushel; (107) Augusta beans, Royal Farms, Windsor Park, 72 lbs. per bushel; (83) beans grown in 1850, on stiff clay soil, near Banbury, destitute of phosphate of lime; specimens of the soil in its natural condition, and of burned clay, with 22 per cent. of phosphate of lime and magnesia added as a dressing.

Kidney-beans (*Phaseolus vulgaris*). (Exhibitors 104, 105.)—The kidney bean of England, the haricot of France, comprises 34 varieties, including the dwarf and climbing sorts. In France, and other parts of Europe, in the Canadas, and the United States, they constitute a field crop cultivated for the ripe seeds, of which various dishes

are made. With us they are only cultivated for the green pods, and that by no means extensively. The kidney bean thrives on light soils of medium fertility, yielding a produce often more than double that of any other legume. The dwarf kinds might be cultivated with advantage in this country, as a substitute for the potato. The ripe seeds boiled, with a small piece of butter stirred among them while hot, and sprinkled with pepper, form a very palatable, as well as nutritious dish, which would be a valuable addition to the cottager's fare.

Peas (*Pisum sativum*), (Exhibitors 92, 94, 73, 83), are divided into four sections:—1. Those suited for field culture; 2. Those suited to field and garden culture; 3. The garden sorts; and 4. The sugar peas, or those whose pods can be eaten entire like kidney beans, from the absence of the tough inner film or endo-carp. Split-peas, pea-dust, and pea-shellings, together with pea-bread, are exhibited in the Lawson Collection. Before the introduction of the potato into general cultivation, peas were used more extensively than at present as the food of the peasantry; and Dr. Buckland has recorded a remark of an old labourer, as to the greater strength derived from a pea diet, and the degeneracy of a potato-eating race. Like all the legumes, they contain a large proportion of a substance analogous to the glutine of wheat, to which chemists have given the name of legumine. In the northern counties, and in parts of Scotland, pea-meal still forms a portion of the flour from which the bread of the peasantry is made.

Lentils (*Ervum lens*). (Exhibitors 103, 105.)—This is a plant which, though introduced at an early period into Britain, has been much neglected. On the Continent it is even more common, as a field crop, than the haricot; and it appears worthy of attention, among us, as a substitute for the potato. At No. 103 will be seen specimens, both of the plant and of the seed grown as a field crop, in 1850, by M. A. F. Guillerez, South Queensferry, and for which the Highland Agricultural Society awarded him their large

gold medal. The flour of lentils, which is sold at a high price, under the name of Ervalenta or Revalenta, as a food for delicate stomachs, is said to afford a meal, in most of the southern countries of Europe, for little more than a farthing for each person. The following are the quantities of starch and legumine contained in peas, kidney-beans, and lentils :—

	Legumine.	Starch.
Peas, per cent. . . .	26·4	43·6
Kidney-beans ditto . .	23·6	43·0
Field-beans ditto . . .	11·7	50·0
Lentils ditto	38·5	32·8

The lentils, however, were dried to that point that they lost 14 per cent. of water, which would somewhat reduce the proportion of legumine and starch, but still leave the former larger than in the other legumes.

Buckwheat (*Polyonum fagopyrum*). (Exhibitors 104, 105.) —Cultivated on poor land as food for pigs, poultry, and game, and for the use of the distillers. In France it is made into bread. We have eaten it in Ireland during the famine of 1847. It is also used in France as food for horses, a bushel of grain being considered equal to two bushels of oats. Bees delight in the flowers.

Secondary or Forage Crops. (Exhibitors 84, 104, 105, 112, 114.)—The grasses and clovers are represented in the Lawson Collection by dried specimens, and by specimens of their seeds; both of which will also be found in the collection of Messrs. Gibb and Co., which contains all the agricultural, garden, and nursery seeds in which they deal. At 84, British Grasses, are also exhibited, at 114; perennial rye-grass seeds from Nairnshire. At 112, seed of purple-topped yellow hybrid turnip, described as valuable for sowing as a substitute for Swedes.

Beet Sugar. (105.)—Messrs. Lawson represent the roots of turnips, carrots, parsnips, mangold-wurzel, &c., by wax models, accompanied by dried specimens of the leaves and flowers, and by samples of the seed. For details, the visiters

to the Exhibition should consult their Synopses. Among the rarer roots, will be seen the white beet, cultivated in France, for its sugar. As there is at present a desire, on the part of the agricultural interest, to cultivate it in this country, it may not be uninteresting to refer to the statistics of sugar-making in France, as collected for the French Government by Dumas, and reduced to English weights and measures by Sir R. Kane, in his "Industrial Resources of Ireland." It appears that the crop does not exceed 12 tons an acre. Thirty or forty tons may be produced by high cultivation; but the carbon in that case goes to form woody fibre, instead of sugar, so that 12 tons is, in effect, the most profitable crop. The value of this to the manufacturer is 16*s.* 8*d.* per ton; at which rate, if he could purchase coals at 12*s.* the ton, the prime cost of the sugar would be 26*s.* 6*d.* the cwt., or 2⅞*d.* the pound, after giving the manufacture credit for the refuse pulp as cattle food, for the skimmings of the boiler as manure, and for the treacle. The value of the crop, therefore, to the farmer, would be 10*l.*, delivered at the sugar works, subject to a deduction for the purchase of manure, which cannot be estimated at less than 30*s.* the acre. The intelligent farmer will compare such crop with 25 or 30 tons of mangold-wurzel, raised as cattle food to be consumed upon the land, and judge for himself of the relative profit attending the growth of each.

It seems, however, that beet-sugar is not to be the only British sugar. At No. 149, we find a small loaf of sugar, made from canes grown in the county of Surrey, whether in the open air or in a hot-house is not stated. In America much sugar is made from one species of maple. Why not, if we must be a sugar-growing country, plant woods of the sugar-maple on soils, of which we have plenty, more suited to woodland than pasture or arable culture, and the value of which, as woodland, is now much reduced by the facilities which the railway system affords for the conveyance of coals to inland districts, remote from the collieries?

Hops (*Humulus lupulus*). (Exhibitors 59, 60, 61, 62, 63.) —Those in Britain are a southern crop. Such strangers are they to the agriculture of Scotland, that in the Lawson Collection they are classed with the medicinal plants, and are represented by a *hortus-siccus* specimen, and their ultimate produce is exhibited as tincture of hop, and essence of hop. In the English part of the Exhibition, allotted to articles used for food, the hop assumes greater importance. We there find a hop-merchant exhibiting (No. 59)—Golding hops, grown in the district called "the Hill," and used for brewing the finest ale. 2. The same grown in East Kent, and used for the finest pale ale. 3. The same grown in the heart of Mid-Kent, and used for the best brown ale. 4. Jones's hops, grown in various parts of Kent and Sussex. 5. Colgate hops, a very hardy plant, grown throughout Kent and Sussex; but the flavour is not much approved. 6. Hops, the growth of Essex and Worcester. At No. 60, we have a bag of hops, grown within three miles of the sea, in the parish of Guestling, Sussex. 63. A pocket of Mid-Kent hops. 61. A pocket of Farnham hops. 62. True Golding hops, grown at Farnham, on the estate of T. M. Payne, Esq., with a notice that, in Class 1, other specimens of the same are exhibited, in connection with the rich beds of phosphoric fossils, on which these hops are grown. He also exhibits Goldings of the early pickings and of the late pickings, and Whitebines of the early and late pickings.

The durability of the Farnham hop-grounds is probably due to the phosphate of lime which abounds in the outcrop of the greensand strata of that neighbourhood. But the delicacy of the hops of that district arises in a great measure from the early period of picking, and the care taken in the process to keep them free from leaves and portions of the bine. They are more used for brewing in private families than by the public brewers.

Hop Mould. (64.)—The hop is a precarious crop, subject to various injuries from parasitic plants and from

the attacks of insects. The most formidable of the former is mould—a fungus, *Erysiphe macularis*, which, in the different stages of growth, produces the black, white, and red mould. It originates in sporules or seeds, and increases by detached cells before it produces spores. It derives its nourishment by imbibing the juices of the hop, on the leaves of which it is developed. At No. 64 is a plate, engraved from Dr. Plumley's microscopic preparation, by Mr. Brett, of Maidstone, forming No. 5 of a series of illustrations of the parasitic fungi of the British farm. This plate exhibits—1. The fungus in the first stage of growth on the hop-leaf, consisting of a delicate superficial thread-like web, composed of elongated cells. 2. It soon produces numerous lateral branches composed of rounded cells. 3. The terminal branches become detached, either singly or unitedly, and fall off in great numbers. 4. Many of the detached cells throw out a thread-like web, and form fresh mould, but the greater portion die. 5. It next produces globular bodies or spores, which throw out fibres in all directions, and are first white (white mould), changing to brown or black (black mould); they then burst and discharge numerous sporidea, containing sporules, or germs of future mould. The red mould of the hop-growers signifies the premature death, partial or complete, of the hop itself, from the fungus arresting its growth.

In consequence of the Excise-duty, on hops we are furnished with accurate statistics respecting their cultivation for a long series of years, which are wanting in other more important departments of agriculture, and which are greatly to be desired. The number of acres under hops in Britain is in a state of constant fluctuation. The culture is confined to a few counties, and Kent has the largest share of it. They are planted not only on land which is suited to them, and on which a hop-ground may be considered perennial, but on unsuitable soils, on which the duration of the plantations does not extend beyond 12 years. A succession of unproductive seasons produces

high prices, and many are tempted to plant. By the time the new plantations reach maturity, the increased breadth of hop-ground, combined with a succession of productive seasons, causes low prices, and a large portion of the inferior hop-grounds are grubbed. The greatest number of acres under hop culture was 56,323 in 1837; the average for the 30 years ending 1844 was 47,870, on which the average annual produce was 6 cwt. 1 qr. 2¾ lbs., and the average price 6*l.* 19*s.* the cwt. The greatest average produce was, in 1808, 13 cwt. 2 qrs. 2¾ lbs., and in 1826, 11 cwt. 0 qrs. 5½ lbs. The smallest average yield was in 1825, 1 cwt. 0 qrs. 8¾ lbs. The highest price during the same period was in 1817, when Canterbury and East Kent hops averaged 28*l.* 10*s.* the cwt.; the lowest in 1821, when the same qualities averaged no more than 4*l.* 4*s.* 6*d.*

Mustard. (119.)—Before we quit Class III., in which are exhibited substances used as food, mustard must be noticed as a product of British agriculture. At 119 are specimens of brown and white mustard, in the state of seed, crushed seed, and mustard flour. White mustard has recently assumed some importance as a forage or fallow crop, to be fed off with sheep, or ploughed in for the improvement of the soil.

Oil-seed Cakes. (66.)—English linseed-cake from Boston, with specimens of linseed-oil and rapeseed-oil. Linseed-cake from Hull, Beverley, Newcastle-on-Tyne, and Dublin.

The oils exhibited in this section belong partly to substances used as food, and partly to those used in manufactures. The principal British oils, and almost the only oils exhibited, are those derived from linseed and rapeseed. Their refuse, linseed-cake and rape-cake, may be considered as substances indirectly applicable to human food, through the sheep and oxen which are fed with the former, and the wheat and turnips which are manured by the latter. Rape-cake is, however, beginning to be used, and successfully, as food for sheep and cattle, mixed with lin-

seed-cake. Mr. Pusey was, we believe, the first to employ it in this way.

Guano. (66.)—By the side of these are exhibited specimens of guano—Bolivian and Peruvian—super-phosphate of lime, and other drill manures.

The importation of guano, which commenced in 1841, has increased to 83,438 tons in 1849, and 116,926 tons in 1850, the money value of which exceeds one million sterling. South America is now the chief source of supply. While that on the African coast was unexhausted, the guano imported in 1845 amounted to as much as 220,934 tons, employing 683 ships. Fresh discoveries are said to have been recently made on the coast of Western Australia.

Bones have been used, in large and increasing quantities, as a manure for turnips, for more than 40 years. Till very recently, the nature of their action on the turnip was little understood; and their principal efficacy was attributed to the gelatine contained in them, as a source of ammonia. Burned bones, however, deprived of their gelatine, were found nearly as efficacious. Liebig insisted that their virtue lay in their phosphoric acid; and he pointed out the advantages which would result from using them in the liquid form, as superphosphate of lime, diluted with water. The earth of bones consists of lime, combined with phosphoric acid, in the proportion of 51· per cent. of lime, and 48½ per cent. of phosphoric acid. Of this compound bones contain about 57 per cent. The horns, hoofs, and nails, as well as the flesh, blood, and excrement of cattle, contain it in smaller quantities. It enters also into the composition of the seeds of all varieties of grain, and is found in the ashes of plants, particularly the legumes and the cruciferæ, to which last the turnip belongs. Phosphate of lime is found, moreover, in all soils distinguished for fertility. As it exists in bones it is insoluble, except very slowly, in water, and that charged with carbonic acid; but it is soluble in sulphuric acid.

New compounds are then formed; the sulphuric acid combining with one portion of the lime of the phosphate of lime, to form sulphate of lime, and the phosphoric acid, combining with a smaller portion of lime than before, forms an acid and soluble superphosphate. The Duke of Richmond was the first to reduce Liebig's hints to practice, by supplying turnips with the soluble phosphate of lime, diluted with water. The success of the experiment led to the manufacture of superphosphate of lime from bones, dried by a mixture of charcoal, or some other drying substance, so that it could be used as a drill manure. It was known to geologists and chemists, that most fossiliferous rocks contain phosphate of lime in small quantities, derived from the animal remains entombed in them. Professor Henslow pointed out the existence of phosphoric nodules in considerable quantities in the beds of sand and gravel, called crag in Suffolk, easily accessible by the wasting of the cliffs from the action of the sea. Mr. Lawes applied them to the manufacture of superphosphate of lime, as a drill manure, and patented the process. Mr. Payne, of Farnham, and Professor Way, the chemist to the Royal Agricultural Society, drew the attention of farmers to the beds of phosphate of lime in the greensand strata near Farnham. The patent of Mr. Lawes, however, prevented till lately any general application of them; but that patent having been set aside by a recent decision of the Court of Exchequer, there can be no doubt that the search for fossil phosphates will be prosecuted with renewed energy. The difficulty will be to find them concentrated in sufficient quantities, and sufficiently free from covering to be profitably worked. Apatite, or native phosphate of lime, occurs in small quantities in mineral veins in granitic and slaty rocks in Cumberland, Cornwall, Finland, and Norway. The massive variety called phosphorite forms beds in Bohemia and Estremadura. It is said also to occur in considerable quantities in some part of North America. If capable of being cheaply worked,

and well situated for transport, there can be no doubt that it will become an article of commerce as profitable to the owners as beneficial to British agriculture.

The advantages which these manures have conferred, within the last few years, on our farmers, may be illustrated by a calculation recently communicated by an extensive and excellent tenant-farmer of the old school, showing that if London manure (which, however, would cost at least 8s. per ton) were given him for nothing, delivered, on the banks of the Thames, to be carted about six miles to a somewhat hilly farm, it would be more expensive to him than the purchase and carriage of an equivalent quantity of guano, bones, or superphosphate of lime.

As a pendant to the Agricultural Produce of Britain, it may be not uninteresting to notice the quantities of similar produce imported during the last two years from foreign countries, and from our colonial possessions, dividing them into substances used as food, and imported for the benefit of consumers—substances imported as the raw material of manufactures—and substances imported to assist British agriculture in the production of both.

Imported for the benefit of Consumers.

		1849.	1850.
Live stock, equal in meat to. . . .	Cwts.	353,130	419,830
Beef, fresh and corned .	,,	5,280	11,752
Beef, salted	,,	144,682	123,662
Pork	,,	348,274	211,247
Bacon	,,	384,696	336,321
Hams	,,	11,751	16,262
Total . .		1,287,811	1,119,074

		1849.	1850.
Butter	Cwts.	279,465	320,560
Cheese	,,	390,962	341,583
Lard	,,	186,373	229,614
Potatoes	Tons	70,893	67,444
Eggs	Number	97,745,849	101,761,995

		1849.	1850.
Wheat	Qrs.	4,507,626	3,778,435
Wheat-flour . .	,,	1,124,718	1,102,380
Barley	,,	1,554,860	1,042,801
Oats	,,	1,368,673	1,167,177
Rye	Qrs.	256,308	94,073
Peas	,,	285,487	182,559
Beans	,,	485,430	449,493
Maize	,,	2,249,570	1,286,281
Buckwheat . . .	,,	308	296
Bere	,,	1,749	571
Oatmeal	Cwts.	40,055	5,839
Maize-meal . . .	,,	102,181	11,401
Rye, barley, bean, pea, and buck-wheat meal . .	,,	26,356	1,234

Imported as Raw Material for Manufactures.

		1849.	1850.
Flax	Cwts.	1,806,673	1,821,578
Hemp	,,	1,061,893	1,048,635
Tallow	,,	1,465,629	1,241,781
Hides, raw and dressed	,,	694,813	608,672
Sheep's wool . . .	Lbs.	75,113,347	72,674,683

Imported for the benefit of British Agriculture.

		1849.	1850.
Bones	Tons	29,424	27,183
Guano	,,	83,438	116,926
Oil-seed cakes . . .	,,	59,462	65,055
Clover-seed	,,	130,254	94,040
Flax-seed	Qrs.	626,495	608,986
Rape-seed	,,	29,840	107,029
Tares	,,	30,623	27,298

Re-exported of the above.

		1849.	1850.
Wheat & wheat-flour	Qrs.	5,924	11,829
Barley	,,	65	13,260
Oats	,,	6,048	6,035
Guano	Tons	16,203	22,575
Hides, raw & dressed	Cwts.	157,160	114,519
Wool	Lbs.	12,324,415	14,054,815

There were not more than 10,702 quarters of wheat and 3,003 cwts. of wheaten flour in bond on the 5th of January, 1851.

The guano, bones, and oilseed cakes imported in 1850, were sufficient to manure at least one million of acres, exclusive of the bones of the imported live stock, and of that portion of the flaxseed and rapeseed which was employed as manure. Much of the maize, oats, barley, beans, peas, &c., having been used as cattle food, must be regarded as so much imported manure.

Preserved Meats, &c. (Exhibitors 12, 14, 15, 20, 21, 22, 24, 26).—Meat and vegetables preserved in various ways so as to keep during long voyages are displayed in profusion, though, from the nature of the substances, it is impossible to judge of their comparative qualities by the eye. M. Appert, of Paris, was the first person who discovered a plan by which meat, vegetables, fish, soups, &c., could be preserved for a long period, and a great many specimens were prepared by him in glass and earthenware, but on a very limited scale. The invention was, in the year 1811, introduced into England, and a patent was granted in the year 1812 to Messrs. Donkin, Hall, and Gamble; and, in consequence of their improvements, substituting tin canisters for the very fragile vessels of glass and earthenware, they were enabled to preserve effectually large portions of meat and other articles of food, and to work the invention on a large scale. They were the original parties to bring this branch of industry under the notice of the British navy and the public, and have on several occasions supplied various expeditions under the command of Captain Parry, Captain Ross, and others, with these provisions, which have given universal satisfaction. In the collection of Mr. Gamble there are some canisters of meat preserved so long ago as 1813, the first instances of this process being used in England. The meat is kept in cases which, after the air has been expelled, are hermetically sealed. Putrefaction is thus prevented taking

place, and the substance kept for an indefinite length of time in a fresh and wholesome condition.

Consolidated Food. (Exhibitors 16, 138, 139, 140.)—Under this head we may class the preserved or consolidated milk, prepared by evaporating the watery constituents of that substance. It may thus be kept during long sea voyages. The combinations of wheat, gluten, and meal, are similarly useful concentrations of food. The most curious form of concentrated food in the Exhibition is a series of bonbons, and other preparations, from the blood of cattle.

Honey. (Exhibitors 1, 2, 4, 5, 6.)—This article is shown in its finest and purest state, and on the north of Transept the bee may be seen at work.

British Wines. (Exhibitors, 8, 10.)—Those who are curious in British wines will be gratified by the contemplation of champagne, sparkling hock, Madeira, and Constantia Frontignac, all home-made, and the first especially noticeable, since it claims rhubarb stalks as its parent.

Chicory. (144.)—Chicory, the root of the *Cichorium intybus*, a plant of the lettuce tribe, is exhibited in all its stages, from the plant to the powder used for mixing with ground coffee.

On the tables of division P. 19, are displayed various modifications of starch, gum, and gluten. English-made macaroni, and bread made from mixture of wheat, rice, and potatoes (151), may also be noticed. A curious substance in the shape of nutritious flour is shown (133), made from the root-stock of the great bulrush, *Typha latifolia*. The part employed appears to be the more cellular portion of the stem. This is placed in the immediate neighbourhood of the samples of hops and linseed, and alongside of a fine display of vegetables preserved in vinegar.

Biscuits. (64).—Biscuits made of the sawdust of pine wood, mingled with gluten of meat in the proportions of two-thirds sawdust, one-third wheat flour, and one twentieth animal matter, are exhibited, as showing the possibi

lity of making any vegetable substance, such as woody fibre, nutritious by preparations with animal matter.

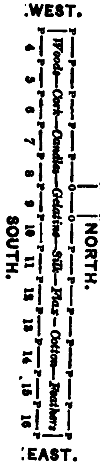
Coffee, Tea, and Substances containing Theine. (Exhibitors 29, 30, 31, 32, 33, 34, 36, 37, 38, 28, 35, 143).—Chemists have discovered that the peculiar properties of tea and similar beverages depend upon the presence of a nitrogenous alkaloid, called *Theine*, because first discovered in the tea-plant. Coffee, cacao, and the maté, or Paraguay tea, belong to the ame category. These vegetables are, however, members of very different tribes, for the tea-plant is closely allied to the *Camellia*, the coffee belongs to the madder tribe, the maté is produced from a species of holly, and the cacao is the seed of the *Theobroma*, an American tree, of the exotic order *Buttneriaceæ*. The name, chocolate, applied to the preparation from the seeds, is a Mexican appellation "chocolatl". The ancient Mexicans knew the value of this plant well, and from them its use was imparted to the Spaniards. Various forms of cacao and chocolate are exhibited, and instructive series of illustrations showing the plant and all the stages of preparation of its fruit and seeds. There are also illustrations of the preparation of coffee; and the Assam Company displays satisfactory evidences of their success in the cultivation and preparation of tea.

Preserved Fruits, &c. (Exhibitors 54, 55, 56.)—Various methods of preserving fruits and edible seeds are exhibited in glass cases and jars. Some are British, but the greater number of foreign origin. Those in the collection of Messrs. Payne and Son are mostly Indian. Among them may be noticed the pistachia-nut and the soy-bean (*Soya hispida*), from which the sauce, soy, is derived. Among the exotic fruits in the collection of Messrs. Fortnum and Mason may be noted the nuts of the hickory; the acuaria nuts of South America, which are the fruit of the *Caryocar*, a large tree. The sapucaya nuts, which are the seeds (not fruits) of the *Lecythis olliaria* or monkey-pot tree, extracted from great heavy fruits with lids, and very similar in nature to the common Brazil nuts; also seeds, the con-

tents of the ponderous fruit of the *Bertholletia excelsa*, both large South American trees belonging to the same natural order.

Spices. (53.)—A glance at the collection of spices will serve to show that they are essentially tropical productions, and almost all derived from the East and West Indies. Carraway and coriander seeds are British exceptions. The nutmeg and the mace are separate parts of the seed of the Indian *Myristica moschata*, the representative of a tribe of tropical trees nearly allied to the laurels. In the last-named family several important spices are derived, such as cinnamon and cassia. Cloves are the flower-buds of the *Caryophyllus aromaticus*, a plant of the myrtle tribe, and allspice or pimento is the dried fruit of other species of the same family. The buds of the common myrtle have been used as spices. Ginger is the rootstock of the *Zinziber officinale*, a plant belonging to a tribe of aromatic herbs, natives of the tropics. Black and white pepper are various states of the berry of *Piper nigrum*, a tropical shrub. The former is the fruit with its fleshy coat remaining, from the latter it has been removed.

Class IV.—Vegetable and Animal Substances used in Manufactures.



Situation of Class 4.—*In the South Gallery immediately to the west of Class* 3; *between the Pillars* O. P. 4 *and* 16.

Position of Groups (Numbers referring to Pillars).—Flowers, Mosses, Plants, Woods, 4 to 5.—Margaric Acid, Cork, Barks, 5 to 6.—Candles, Spermaceti, Wax, Gelatine, 6 to 8.—Mother-of-pearl, Palm-oil, 8 to 9.—Raw Silk, 9.—Flax 9 to 11.—Wax Candles, Sealing-wax, 11.—Cotton, Hemp, Cordage, 11 to 12.—Wools, Hair, Thread, 12 to 13.—Quills, Feathers, 14 to 15.—Woods, Colouring Matter, Carmine, 16.

The principal products of British agriculture exhibited in this class are wool and flax.

Wool. (Exhibitors 78, 80, 81, 84, 85, 86, 88, 91, 94.)—Of wool we have:—The skin of a pure Southdown ewe, stuffed, which lived to the age of seven years, without being shorn. Length of wool, 25 inches, weight, 36 lbs. Fleeces of Cheviot wool, grown in Northumberland, at an elevation of 2,600 feet above the sea. Long-combing Merino wool, of English growth, from near Chichester—the last remnants, probably, of those Merino flocks which it was attempted, in vain, to naturalise in England, and which appear better suited to the climate of our Australian colonies. Southdown wool, which is generally of a fine character, and fitted for the more delicate kinds of woollen manufacture. Associated with this is also Diamond teg, matching wool from Southdown fleeces, grown in Wiltshire, showing the peculiarities of the different breeds. Fleeces of Irish long wool, grown in the counties of Meath and Galway; long wool and short mountain wool from the county of

Wicklow; and fleece of Leicester wool, county of Kilkenny. Various kinds of wool exhibited by the Sectional Committee of the Animal Kingdom. Specimens of "burry" wool, in the original state, and cleaned by machinery. English, mohair, and Australian wool, with samples combed without oil, and the fleece of an aged ewe, Highland breed, unlaid.

Flax (*Linum usitatissimum*). (Exhibitors 40, 43, 45, 46, 47, 49, 54, 105, 106.)—Referring back to the Lawson Collection, in Class III., we find specimens of flax grown in Britain from British, Dutch, and Riga seed. The English is considered to produce the best fibre, and the foreign the best linseed. The Sectional Committee of the Vegetable Kingdom supplies samples of the ordinary flax and hemp of commerce: French, Flemish, Dutch, Friesland, Archangel, Riga, *English*, Egyptian, and New Zealand flax, Petersburgh, Riga, American, Egyptian, Indian, Manilla, hemp and jute. The seeds of flax and hemp, chemically prepared, are exhibited with samples of flax straw, and of the flax in different stages of preparation. Specimens of the fibre of Belgian flax, and of yellow flax from Trimingham, Norfolk, and blue flax from Yorkshire, together with flax grown in Yorkshire, raw and manufactured, prepared flax and flax-seed, grown near Crewkerne, and flax grown, steeped, and scutched, at Yately, North Hants, in South Hants, and at Cobham, Surrey; flax grown and scutched at Farnborough workhouse; flax scutched by the prisoners in the county gaol, Winchester; refuse tow, manufactured at Yately; coarse tow; and models of tools made and used at Yately. Specimens of flax exhibited by the Royal Belfast Flax Improvement Society, grown in different parts of Ireland, showing the heckled flax of various degrees of fineness. The dependence of the profit of flax cultivation on the degree of care and skill bestowed in "handling" the flax, or preparing the fibre for market, is illustrated by specimens of flax from Monaghan, value 38*l.* to 45*l.* per ton; Tyrone, 42*l.*; Down,

48*l.* to 52*l.*; Armagh, 47*l.* to 54*l.*; Antrim, 68*l.* to 100*l.* Handspun thread, and thread spun from flax prepared by Schenk's patent process of steeping it green in hot water, are interesting examples. (105.) Samples of flax in every stage of manufacture from the straw to cloth, prepared by Claussen's patent process for spinning on cotton, wool, and silk machinery, as a substitute for, or auxiliary to, those substances—twist and yarn, dyed and undyed, produced from flax—flax cotton—flax wool—flax silk—and woven into cloth and various other articles. Also hemp and other fibrous plants, prepared either wholly, or in part, by the above process.

To explain the nature of the process, it is necessary first to explain the structure of the flax-plant. Its stem consists of—1st, the shove, or wood; 2nd, the pure fibre; and 3rd, the gum, resin, or glutinous matter which causes the fibres to adhere together. In preparing the plant for any purposes of fine manufacture, it is necessary to separate the pure fibre from the woody part and the glutinous substance. In the ordinary process, this is done by means of the fermentation produced in the tedious and noxious operation of steeping in stagnant pools and retting, by which putrid products and noxious exhalations are diffused over the neighbourhood, and by which a loss is incurred of those parts of the plant which, if returned to the soil, would cause it to be anything but an exhausting crop. Schenck's patent process accelerates the operation, and removes some of the objections to steeping, by using hot instead of cold water. Claussen's process consists of three stages. In the first the straw is passed through the rollers of a hand-machine, costing 10*l.*, by which the greater portion of the woody fibre is removed. The flax, so prepared, is reported by the Royal Flax Society to be well adapted for the manufacture of sail-cloth, canvas, nets, bags, and other coarse articles. The flax, thus reduced in bulk to one-fourth, may be prepared for spinning, in the ordinary way, into finer fabrics, by the

steeping process, either in hot or cold water; and the farmer, having thus brought his crop into a marketable state, may dispose of it to establishments where steeping is carried on, for the purposes of those manufactures for which that process is still deemed an essential preparation. He will have retained, moreover, to be returned to the soil, the woody matter, the seeds, and the husks of the capsules, which, by the ordinary steeping process, are lost. These are the exhausting portions of the crop, which, with the glutinous matter, contain the substances derived from the soil, the fibre being composed almost exclusively of materials derived from the atmosphere, carbon, oxygen, and hydrogen, with about two per cent. of mineral substances.

The next stage of the Claussen process is directed to the effectual removal of the glutinous matter. The wood may be removed by mechanical means; but the glutinous portion will only yield to chemical processes. The fermentation induced in steeping is a chemical process; but it only partially removes the gum or resin, a large per centage of which is insoluble in water. M. Claussen, therefore, has recourse to boiling, for about three hours, either in the state in which it comes from the field, or in a partially cleaned condition, in water containing about one-half per cent. of caustic soda. After undergoing this process, the flax is placed in water, slightly acidulated with sulphuric acid—1 of acid to 500 of water. A complete separation of the fibres is thus effected. They may then be used, either for spinning, as long fibre, into linen, or may be submitted to the third stage of the Claussen process, by which they are converted into short fibre, or flax cotton. In the former case, the flax only requires to be dried and scutched in the ordinary way.

The principle of the process for the production of short, or cotton fibre, consists in the destruction of the cylindrical or tubular structure of the fibre, by means of carbonic or other acid, the action of which splits it up into a num-

ber of filaments, the upper and under surfaces of which are segments of circles, and the sides of which are ragged and serrated like the fibres of cotton.

To effect this object, the flax, either before or after the process of boiling for the severance of the fibres, is cut into short lengths by a machine, and saturated in a solution of sesquicarbonate of soda (common soda) a sufficient time to allow of the liquid entering completely every part of the small fibres. It is then immersed in a solution of dilute sulphuric acid—1 of acid to 200 of water. By the action of the acid on the carbonate of soda, carbonic acid is liberated, the expansive powers of which split the tubes into thin filaments. "Means shown in their result to be so powerful, and in their operation so gentle, yet decisive, gave to the simple experiment made in the presence of the Council by Professor Way, more the air of a new instance of natural magic than the sober reality of an ordinary operation of natural laws, of which the application only was novel; and its effects on the meeting, accordingly, were both singular and striking; occasioning evident marks of their agreeable surprise and admiration of the result obtained. The flax fibre, soaked in the solution of subcarbonate of soda, was no sooner immersed in the vessel containing acidulated water, than its character became at once changed from that of a damp rigid aggregation of flax to a light, expansive mass of cottony texture, increasing in size like leavening dough, or an expanding sponge. The change was no less striking when this converted mass, in its turn, was placed in the next vessel, which contained hychloride of magnesia, and became at once bleached, attaining then the colour as it had just before received the texture of cotton."*

Assuming the success of the Claussen process in its different stages, the following may be recapitulated as its re-

* From Mr. Hudson's Report of some Experiments performed by Professor Way before the Royal Agricultural Society, illustrative of Chevalier Claussen's process.

sults. In the first stage it will enable the farmer, by mechanical means, and with little trouble and expense, to reduce the bulk of his flax crop, so as to give him access to markets and render it marketable. It will enable him at the same time to preserve, to be returned to the land, those portions of the crop which tend to exhaust the soil; the produce being a description of fibre adapted to the coarser kinds of the flax manufacture. By the second, or boiling operation, the long, troublesome, and noxious process of steeping may be dispensed with, in the preparation of flax for the finer purposes, for which long fibre is spun in the ordinary way. Lastly, by reducing the flax to short fibre, and by splitting it up by means of the chemical process above described, a great extension of the demand for flax may be expected, to be spun on cotton, wool, and silk machinery alone, or in combination with any of those substances. All these results will have been obtained through microscopic researches into the structure of the flax plant, and the application of chemical knowledge to the improvement of old processes for preparing it for use.*

Miscellaneous. (Exhibitors 21, 32, 42, 57, 58, 59, 60, 76, 121.)—Among the miscellaneous specimens of British Agricultural Produce, the following require notice:—42. *Wheaten straw paper;* 32. *Silk* produced by the silkworm, fed on the leaves of the white mulberry, in Surrey—one of those attempts which have been made from time to time, to naturalize in this country, this, and other products of more genial climates; 76. *Woad:* this plant and madder were once extensively cultivated as dye-plants, but have been superseded by the superior and cheaper colours obtained from indigo, logwood, cochineal, and other exotic products. Woad still enjoys the traditional reputation of being the dye with which the ancient Britons painted their bodies, and figures in the clauses, which are

* For further details consult Chevalier Claussen's pamphlet, "The Flax Movement." Effingham Wilson, Royal Exchange.

copied mechanically from lease to lease, prohibiting the cultivation of flax, hemp, and woad. Of madder, we have now scarcely a trace, except in the name of "Madder Market," borne by one of the streets of Norwich. At 121 is seen crown glue, made from the horns and hoofs and feet of cattle; there is also the *Parchment and Glue* of Irish manufacture, *Fish* prepared for manure by creosote oil, and *Quills, Feathers,* and *Horse-hair*, raw and manufactured.

Collections of Woods. (Exhibitors 6, 8, 9, 14 in South Gallery; and Exhibitors 134, 135, 136 Ground Floor.)—In many parts of the Exhibition there are very beautiful and extensive collections of specimens of woods, as well as single examples. In the South Gallery the most remarkable sets of specimens of any considerable extent are those of the Scottish woods in the Collection of Vegetable Productions of Scotland; the large and very interesting geographically-arranged series of 700 and more specimens exhibited by Mr. Wilson Sanders (9), and the English and foreign woods (6) of Messrs. Harrison, of Hull. There is also a very complete set of woods used in turning from Holtzapffel and Co. On the *Ground Floor, South Wall*, is a fine series of foreign hardwoods used for cabinet work, turnery, dyeing, and machinery, exhibited by Messrs. Fauntleroy and Sons, and that of English-grown woods exhibited by Mr. Cross.

Vegetable Dyes. (Exhibitors 68, 70, 72, 75, 76, 77.)—In several of these collections dried specimens of the plants from which the dye-stuff has been derived are placed alongside of their products.

Among those which furnish red dyes, the orchil and cudbear-producing lichens, occupy considerable space, and are very fully illustrated. These plants are of very low organization: in their anatomical structure they are entirely cellular, and they belong to the flowerless division of the vegetable kingdom. They are found in all parts of the world, growing in the most barren situations,

forming crusts and leathery ramified expansions on the bare rock, or coating the trunks of aged trees. Their commercial value varies, however, considerably in examples from different localities; and the same species collected in different places may furnish greater or less quantity of colouring matter. A seaside situation and climate would seem to be especially favourable, since we find that the Atlantic islands, and the coasts of Africa and Peru, furnish the lichens most valued in commerce. The Canary and Cape de Verd Islands are especially famous for these plants. The most valuable is that from Angola. Their properties were known to the ancients, and they were gathered for dyeing in the islands of the Grecian Archipelago. The art was lost, but revived in the early part of the 14th century, when a Florentine merchant rediscovered it in the Levant, and turned it to effectual account in the making of his fortune. The orchilla weed is of a whitish or greyish colour, and leathery texture. The dyes procured from it are mostly shades of red and violet, also blue. It is imported in its natural condition. The colouring matter is extracted by means of ammoniacal solutions. Orchil liquor is the result. Litmus, or turnsole, is procured from the *Rocella tinctoria*, and other orchil lichens, by maceration in urine, lime, and potash. Cudbear—a term curiously enough derived from Cuthbert, the Christian name of Dr. Gordon, who was manager of the first manufactory of it, at Leith, during the latter part of the last century—is a powder of a purplish-red colour, procured from lichens in the manner of orchil.

Orchilla weed is imported in considerable quantities, and from many countries. As much as 4,175 cwts. of it paid duty in England in 1840. Many of our native lichens are capable of being used for dyes. Dr. Stenhouse, who has investigated the colorific principles of the orchil lichens, finds that in *Rocella tinctoria*, the Lima weed, it depends on alpha-orsellic acid; in *Rocella hypomecha*, the Cape of Good Hope weed, on beta-orsellic acid; and in

Rocella fuciformis, that of Angola and Madagascar, on erythric acid.

A very beautiful pink or carmine dye, the *ponceau* of dyers, is procured from the safflower, bastard saffron, or *Carthamus tinctorius* (75), an Indian plant of the thistle tribe. The colouring matter is obtained from the flowers, which are of a deep-red colour. The flowerets of the head of flowers are gathered as rapidly as they open, and dried carefully in the shade. They are purified by maceration in water from a yellowish matter that injures their brilliancy, and the residue is made into the cakes used in commerce. These yield their colouring matter by chemical treatment, it being first extracted by means of a weak alkaline solution, and then precipitated by an acid, usually the citric acid. Vegetable rouge is this substance mixed with finely-powdered French chalk or talc.

Of other vegetable dyes exhibited in these collections we find indigo itself, which will be more fully noticed when the Indian collection is described; it is the product of certain Indian plants of the pea tribe, various species of *Indigofera*, especially *I. tinctoria*, and others that are natives of America, and is procured from all parts of the plant. Madder is derived from an European plant, the *Rubia tinctoria*, one of the family *Rubiaceæ*, and is extracted from the roots. Some other rubiaceous plants, natives of the East, furnish similar dyes. Weld is a yellow dye, furnished by a plant indigenous to the British Islands, the *Reseda luteola* a species of the same genus with the mignionette, but much of it that is used in commerce is imported from abroad. The whole plant is gathered after the seeds have commenced to form. The colour extracted from them is fixed by a mordant. Quercitron, another yellow dye, is derived from the bark of the *Quercus tinctoria*, a kind of oak, native in North America. Fustic, also a yellow dye, is the colouring matter of the wood of an American tree of the mulberry tribe, the *Maclura tinctoria*. Sumach, sometimes also called fustic, and indeed

the original holder of the name, is a yellow dye-wood, the produce of the shrub so called, the *Rhus cotinus*, a native of the countries around the Mediterranean. Arnatto is an orange dye (used also as a colouring matter for cheese), derived from the seeds of the *Bixa orellana*, a South American tree. Turmeric is procured from the roots of the *Curcuma longa.*

Woad (76) is the blue dye with which the ancient Britons stained their bodies. It is the produce of the *Isatis tinctoria*, a plant of the kale tribe, native in a great part of continental Europe and in the southern counties of Great Britain. It grows to a height of three or four feet, and bears small yellow flowers that produce rather large and peculiar pods. It is cultivated for its dye. The plants, when on the eve of flowering, are mowed with a scythe, washed in water, and sun-dried; they are then ground into a paste, which, after being kept in carefully-protected heaps for about a fortnight, are then formed and pressed into solid balls. These are powdered with mallets; the powdered mass is moistened with water, and permitted to ferment—a treatment that goes on for about twelve days. To the powder now prepared, boiling water is added, and after standing in a close vessel for some hours, it is submitted to a fresh fermentation after the addition of a regulated quantity of newly-slacked lime, and being frequently stirred whilst under the influence of a gentle heat. The liquor, so concocted, dyes of a greenish colour, which, on exposure to light, changes to blue. This colour is of the same nature with indigo.

Gelatine, Isinglass, &c. (Exhibitors 117, 118, 119, 120, 121, 122, 123, 125, 125A, 131.)—Gelatine is an animal substance, obtained by boiling chiefly from skins, cartilage, and membrane, but also from bones and flesh. It is scarcely acted upon by cold water, but is soluble in boiling water. Isinglass is one of the purest forms of it, and is procured from the air-bladders of different species of sturgeon. Other parts of this fish are

also used to make isinglass; and the swimming bladders of cods and other fishes furnish an inferior sort. It is much used both as a valuable article of food and for the dressing of silk manufactures. The Caspian Sea furnishes a considerable amount of isinglass, that great inland sea being a favourite resort of sturgeons. Glue is dried gelatine made from parings of hides, refuse of leather, refuse of tanneries, old gloves, parchment—animal skins, in fact, in any form. Considerable skill is required for its manufacture, so that the qualities of glue vary much, and its cohesive properties are very different in different specimens.

Cocoa-nut Fibre. (56A.)—This material is derived from the husk of the cocoa-nut, and forms an essential part of the fruit, analogous to the fleshy portion of the fruit of the peach. It has long been used in the East for making cordage, and experience has shown that its qualities are highly to be esteemed. It is called "coir." Its use was discovered by the feathered creation before found out by man, since several exotic birds that construct pendulous nests employ the cocoa-nut fibre for this purpose. The nut when intended to be converted into coir is cut before it is quite ripe. According to Mr. Marshall, a man can clear 1,000 nuts from their husks in one day, by forcing them upon the point of a spike of iron or wood fixed in the ground. After being soaked in water for several months, and being well beaten with a piece of heavy wood whilst placed on a stone, the fibrous portion of the husks is separated and cleaned by the hand. The fibres are then twisted into yarn. They possess great elasticity and strength.

Tobacco and its Preparations. (Exhibitors 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 52.)—The display of cigars, snuffs, and other modifications of the tobacco leaf, must be highly satisfactory to all epicures in smoking and snuffing, since judges are agreed that finer specimens of these articles of luxury have never been produced. The tobacco

plant, *Nicotiana tabacum*, is an herb belonging to the same natural order with the potato and night-shade. It is a native of America, and was introduced from the new world into Europe. Its properties were well known to the Indians, who surprised Columbus and his companions by their cigar-smoking. In less than a hundred years after, the habit of smoking tobacco became general in Europe, and has now grown almost into a necessity, in spite of the fiercest opposition. There is reason to believe that the Asiatics had obtained the plant and smoked its leaf long before the Europeans. The southern states of North America are now the greatest cultivators of this herb. Some botanists consider the various kinds of smoking tobacco as being derived from different species, restricting the *Nicotiana tabacum* to the Virginian. The large-leaved Oronoko is their *Nicotiana latissima*, of the leaves of which the large Havannahs are said to be made; the Turkish and Latakia are from *Nicotiana rustica*, the variety commonly cultivated on the Mediterranean region; the Shiraz, or Persian, is from *N. Persica;* the small Havannahs, or Queens, are derived from the *Nicotiana repanda*, grown in Cuba. Commercially, tobaccos are distinguished into the unmanufactured, or leaf, and the manufactured, the latter including 1st, those for chewing and smoking, divided into *cut*, which consists of moistened and compressed masses of the leaves chopped up; *spun, roll, or twist;* and *cigars and cheroots*, the former American, the latter Asiatic in origin, though, as may be seen in the collections exhibited, very excellent specimens of both are made in England. The specific character of a cigar as distinguished from a cheroot is the twist at its ends, whereas the latter has truncated extremities. 2nd. Those for snuffs, divided into *dry snuffs*, such as Scotch, Welsh, Irish, Spanish, and *rappee*, which are snuffs prepared by grinding down tobacco when moist. The peculiar qualities of tobacco chiefly depend on an alkaloid called nicotina.

Desiccated Woods. (Exhibitors 20, 12, &c.)—The length of time required for the seasoning of timber is often so great as to be a source of considerable inconvenience. In the natural course of drying, three or four years are often necessary before the wood is in such a condition as to be properly fit for use. Many attempts have consequently been made to attain the end desired more rapidly through artificial means. The specimens of patent desiccated woods prepared by Mr. C. H. Newton are examples. They include various portions of English and foreign woods, prepared on one side and rough on the other, the preparation having been effected in a few weeks. "The process consists in heated currents of air being constantly forced into a large chamber, into which the wood has been carefully packed on its edge, with space between every plank to admit of the heated air passing on all sides. Ventilators are provided at the top of the chamber, so that the currents of air having performed their duty, and become charged with a certain amount of moisture, are allowed to escape, their place being supplied with fresh rarified air." Wood so seasoned is said to be improved in quality. The great organ built by Willis, and placed in the Exhibition, was made from wood cut from wet logs, and seasoned in six weeks by this process. Polished specimens of several woods not often employed for ornamental work, but capable of being thus seasoned and of being so used, are also displayed.

Various applications of the bog-wood of Ireland to ornamental purposes are here displayed, such as whatnots, card-racks, and inkstands, made of Irish bog-oak and bog-yew. The wood found in the bogs of Ireland in a sub-fossil state is often of beautiful colour and compact texture, so as to be excellently adapted for carving. The oak so found is black; the yew of a sober quaker-brown hue. Jewellery, cabinets, and furniture, carved out of Irish bog-wood, are displayed in other parts of the Exhi-

bition in the North Transept Gallery and in the Fine Art Court.

Along with these bog-woods is a section taken from a remarkable mulberry tree, 400 years old, that grew at Trinity College, Dublin, and was blown down during the last great storm.

A series of illustrations of the bog-timber of Ireland is ranged against the wall (12).

Preparation of Plants. (Exhibitors 2, 3, 4, 5.)—Several very beautiful groups of anatomised leaves, flowers, and fruits, display the minute ramifications and elegant arrangements of the fibrous and vascular framework of plants. The skeletons of the organs of monocolytedonous plants, such as grasses, lilies, and palms, are very differently disposed from those of dicotyledons, as oaks, crossworts, and geraniums. The cellular tissue of the organs is removed from the fibro-vascular portions by maceration. Among the specimens exhibited are several that show how the calyx and corolla of the flower, and the framework of fruits, are made out of distinct leaves, arranged in whorls, and organically united together.

An ingenious attempt has been made (3) to preserve flowers in their natural shape, so as to display their several parts without the compression incidental to herbarium specimens.

Of a very different order are the mock flowers (4), cut out of turnips, &c., for the purpose of garnishing meat. Considerable ingenuity and taste are shown in the products of this peculiar occupation.

Membrane.—Goldbeater's skin (Exhibitors 107, 108). This curious substance is displayed in all its stages of preparation, and combined with gold as an ornamental fabric of much beauty. The "skin" is a fine layer of prepared membrane separated from the outer surface of the intestine of the ox. The body is given to it by moistening with an infusion of aromatic spices. The value of

the substance, notwithstanding the commonness of its origin, may be understood, when we recollect that each of the little bundles shown is the produce of no fewer than 100 oxen. A goldbeater's mould of France or Belgium contains 1,200 leaves, and the product of 750 oxen is required to make it. The English and American goldbeater's mould contains 850 leaves, and is the product of 500 oxen.

China Grass. (Exhibitors 42, 45, 55.)—The beautiful fibrous substance, called China grass, is of comparatively recent introduction into this country. It is the fibre of a species of nettle, the *Urtica*, or *Boehmeria nivea*, a native of several countries in the east of Asia, and especially of China, whence it is imported. It is exhibited in all its stages, and converted into thread-yarn and textile fabrics, pure and mixed with other fibres, or with wool.

Veneers. (19.)—Some beautiful veneers of walnut and rose-wood are suspended against the wall. By means of veneering, which is the sawing, either by hand or machinery, of thin leaves of wood, and then gluing them down on boards of other woods of less value, comparatively small portions of the rarest and most beautiful kinds of ornamental woods may be made to cover a large surface.

Feathers (Exhibitors 57, 59, 60) are shown, according to their various uses, along with hair for stuffing beds, &c., and also as quills and pens. They form a very considerable article of commerce. The yellow tint of many quills is given either by weak muriatic acid, or by steeping them in a decoction of turmeric. The fine outer feathers of a goose's wing make the best quills for pens.

Whalebone. (Exhibitors 103, 104.)—An interesting series of specimens, illustrative of the whalebone manufactures, are exhibited by Westall and Co. The "fins" of whalebone contained in this case are triangular plates of this substance with fringed margins that hang vertically from the upper jaw of whales of the *Balæna* group.

These plates are arranged in longitudinal series, and their bristly margins serve as filterers to arrest the course of small jelly fishes and floating mollusks; these little creatures are the chief food of the whalebone-whales. They are very numerous, and the middle ones are largest. All whales are not provided with them, and in the Finner, or hump-backed, whales, the plates are very much smaller than in the Right whales. The finest pieces of whalebone shown are from the great Greenland whale, *Balæna mysticetus*. Others are exhibited, the product of nearly allied species; and also some from the Finner, or *Balænoptera boops*, an animal so rapid in its motions that it is extremely difficult to capture. Some curious and elegant applications of whalebone manufactures are placed along with them, such as an elegant bonnet made of the shreds of whalebone, rosettes and other ornaments for horses, baskets and reticules, &c.

Preserved Timber. (Exhibitors 7, 21.)—The preparation of timber, so as to prevent or arrest its decay, and to enable it to resist the attacks of animals and vegetables that destroy its substance, has been attempted by various inventors, and several patents have been taken out for various methods of effecting this desirable object. On the wall are suspended a number of specimens (21) illustrative of this subject, in connection with the patent of Mr. Bethell, who saturates timber with the oil of tar, and terms the process "creosoting." Examples of creosoted sleepers, that have been in use for several years on lines of railway, and creosoted piles that have remained in the sea unimpaired for four years in Lowestoft harbour, are shown. Alongside of them are placed portions of unprepared wood perforated by marine animals. One of these is bored by long and capacious tubes, the work of the *teredo*, or ship-worm, a curious vermiform shell-fish, very destructive to the timber of vessels and the piles of harbours. Another is riddled as effectively, but more minutely, by the *Lim-*

noria terebrans, a very small crustacean animal, equally destructive with the shipworm.

Another mode of preparing timber, with the like object, is that invented by Sir William Burnett. and termed "Burnettizing." The substance forced into the pores of the timber in this method is a solution of chloride of zinc (7). It is applied also to the preservation of canvas, cotton and woollen cloths, and hides. On the South Wall on the ground-floor will be seen some other specimens, in which the pores of the timber have been filled in with oxides of iron, which is stated to give high durability to the wood, and fit it for many purposes to which it could not be otherwise applied.

Spermaceti (Exhibitors 4, 24, 25, 29) is an oily substance contained in the cellular cavities of the upper part of the cumbrous head and snout of the sperm whale. This matter, when first extracted, is enclosed in hair-bags, pressed, melted, and boiled in a weak solution of potash and alcohol. It is then cast in moulds, and is turned out in a crystalline condition. The whale which furnishes it, and of whose lower jaw, with its characteristic ivory teeth, a fine specimen is placed in the Nave, leaning against the pile of Canadian timber, is very different from the Greenland or whalebone whale. Besides spermaceti it yields sperm oil; both substances are exhibited, with the manufacture of the former into candles, and alongside of them are specimens of wax applied to the same purpose.

Animal and Vegetable Oils. (Exhibitors 23-26, 27, 28, 30.)—In this department are also various oils, some derived from the animal, some from the vegetable kingdom. Among the latter are various forms of vegetable tallow, a substance furnished by several plants of very different families, and palm-oil, the product of the *Elais Guineensis*.

Raw Silk. (Exhibitors 34, 35, 36, 32.)—In the case of raw silk exhibited by Messrs. Durant & Co. there is a fine display of the various kinds that find their way into the

British market. Case No. 32 is very interesting, on account of its contents being of British origin. Here we have raw silk spun in this country, and woven into hose. No. 36 exhibits the raw silk in connexion with the various dyes with which it is coloured.

The *Bombyx mori*, or silkworm moth, is an insect originally derived from China. The silkworm is its caterpillar, and the silk is the cocoon spun by it for a protecting case during its chrysalis stage. The Chinese appear to have turned the labours of the insect to account at a very early period, and exported silk in the time of Aristotle. The experiment of breeding silkworms for their produce was commenced in England under the auspices of James I., when great numbers of mulberry trees were planted to provide the insects with food. China, India, Persia, and Italy have supplied most of the specimens of raw silk exhibited in these cases.

Pitcher Plants. (2 *a.*)—A case of dried pitchers, from various kinds of pitcher-plant (*Nepenthes*, *Dischidium*, *Saracenia*, &c.), illustrates a very curious natural transformation of leaves, so as to convert them into water-holding vessels.

Near these (129) are the pistachio-nut and the patchouly plant.

Sealing-wax. (Exhibitors 21, 58, 116A, 73, 93.)—This substance is exhibited along with the materials of which it is manufactured, viz., shell-lac, turpentine, and vermilion, for red wax; the last-named pigment being replaced by lamp or ivory black in black wax. The shell-lac is the ingredient upon which its value depends. Lac is a reddish resin, formed on the twigs of various Indian trees, chiefly species of fig, in consequence of the puncture of an insect, the female of the *coccus lacca.* The twigs encrusted with the resinous substance are brought into commerce as stick-lac. When it is removed from the twigs, pounded, triturated with water, and separated from the colouring matter, it becomes *seed-lac.* When this is melted and strained

through cotton bags it is *shell-lac*. *Lac-dye* is an infusion of ground stick-lac. It is used as an orange-scarlet dye.

Wafers are shown in the same collections with the sealing-wax. The common kinds consist merely of flour and water made into a paste, and coloured with various dyes. Transparent wafers are made of fine glue or isinglass.

Cochineal (56) is the product of an insect very like that from which we derive lac, a species of *coccus*, also the female. It lives on *cactus* plants. Carmine is manufactured from it.

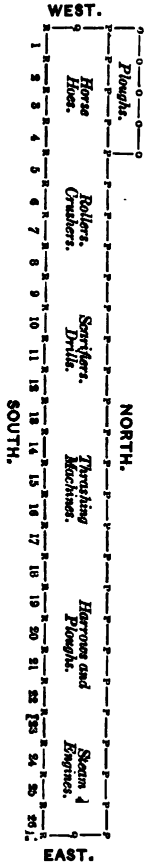
Resins; Varnishes. (Exhibitors 62, 63, 64, 74). — Varnishes are solutions of resinous substances becoming solid in consequence of the evaporation of the solvent and resisting air and wet. Various resins are used, and various degrees of excellence attained in their manufacture.

Insects in Turpentine. (61).—Near these are shown cases containing insects taken out of raw turpentine. They are interesting as illustrating the presence of insects in amber, which is a fossil resin, the product of some ancient coniferous tree. The insects in amber are, however, unknown species, now apparently quite extinct. Very rare kinds of existing insects are sometimes found entangled in raw turpentine.

Mother-of-Pearl. (Exhibitors 109, 111.)—This beautiful substance, now so extensively used in papier-maché manufactures, is the nacreous layer of certain shells. The most common form of it is the produce of several species of *Avicula*, a bivalve shell abounding chiefly in tropical seas, and nearly allied to the oyster and scallop. The Indian and Pacific Oceans furnish the greater part of the *Avicula* used in commerce. Several distinct species are imported for this purpose. The green-ear shell, used for inlaying along with the *Avicula*, is a *Haliotis*, or ear-shell, a univalve intermediate in its characters between a *Trochus* and a limpet. Some large kinds are brought from New Zealand for this purpose; and the only species inhabiting

the European seas, the *Haliotis tuberculata*, is collected in Guernsey, and exported for its mother-of-pearl. A large species of *Turbo* is brought from China with the same object, but especially to be used in the stronger kinds of pearlwork, such as making handles for knives, &c. Cameos are mostly cut on the shells of a species of *Cassis*.

Class IX.—Agricultural and Horticultural Machines and Implements. Division I.



Situation of Class.—*Extends from the Sculpture Court to the West End of the Building; Minerals on the South side; Hardware on the North. Between Pillars* P. R., 1 *and* 28, *and it extends on the Western end to Pillar* O. *from* 1 *to* 4.

Position of Groups.—In this Class, the collections of the different Exhibitors are kept together; and as these frequently contain most of the implements employed in husbandry, it is not practicable to indicate any especial groups.

Although the number of implements exhibited on this occasion is not quite equal to that usually seen at the annual shows of the Royal Agricultural Society, still we have here fair specimens of those implements in general use by our most advanced agriculturists, and also some few others which are now for the first time introduced to the notice of the public. For the convenience of more readily leading the attention of the reader to the different articles exhibited, we have arranged them under four divisions, each of which will comprehend those implements most prominently pertaining to it; and to these four a fifth is added, in which will be found those articles which are to a greater or lesser extent, in use by farmers, but which cannot very suitably come under the other divisions.

No. 1 comprises machines or implements which represent power, such as—

Steam Engines { Locomotive. Fixed.
Thrashing Machines.

Winnowing Machines.
Shaking Machines.
Cutting Machines { Turnips. Chaff. Corn. Grass.
Crushing Machines { Cake. Corn. Gorse. Linseed.
Tile and Brick Machines.

No. 2. Machines or implements operating on the surface, as—

Rollers, Crushers.
Harrows.
Rakes { Horse. Hand-drag.
Horse Hoes.
Ploughs, Paring.
Scarifiers.
Drills.
Seed Barrows.
Dibbling Machines.
Scythes.
Sickles.
Hay Tedding Machines.

No. 3. Machines or implements operating below the surface—

Ploughs { Horse. Steam.
Digging Machines.
Cultivators.
Draining { Ploughs. Tools.
Spades.
Forks.

No. 4. Machines used in the manufacture of farm produce—

Mills.
Cyder Presses.
Cheese Presses.
Churns.

No. 5. Machines or implements auxiliary to a farm establishment—

Carts.
Waggons.

Weighing Machines.
Steaming Apparatus.
Sheep Dippers.
Feeding Troughs.
Beehives, &c. &c.

The application of machinery generally has been most beneficial to agriculture, and has probably contributed more towards its advancement and towards the social improvement of the labourer, than any other of the numerous circumstances affecting land. In districts where the work of the farm is carried on by manual labour, the man is valued more according to his physical than to his mental qualifications: the latter is probably neglected or checked, as tending to make him dissatisfied with his condition, or at all events, as being useless to, or interfering with, the machinery of his muscles, and thus lowering his animal value to his employer. In such a district, the introduction of machinery is generally viewed with suspicion and distrust, from an idea that, by replacing manual labour, it must injure the existing labourer. But a little consideration will soon convince us of the error of such an opinion, as *the machine* can only represent *one* power, the physical, (strength), whereas *the man* consists of *two*, the physical (strength), and another the mental, or power of the mind (skill), to which the first is materially subject. If, therefore, we wish to improve the condition of the labourer and to develop his power, which is his value, to its fullest extent, we are acting in our own interest in giving up as much as we can of the *merely* physical (strength), in order to cultivate as much as possible the higher and more valuable faculties, those of the mind (skill). In this the interest of the employer is surely as deeply concerned as that of the employed. Here it is that the machine comes to our assistance; by it we can readily and profitably replace that which we wish to give up, and the advantages thus gained enable us to devote more attention to that which it is our interest to cultivate. Made of materials far more durable than thews and sinews, insensible to

fatigue, supported and kept in order at far less cost, always ready to work when required, *the machine* is yet incomplete, is indeed useless, unless it is set in motion and regulated by the controlling power of *the man.* By its aid the labour of the man is more equally divided—*both* his powers (physical and mental) are called into play—his value has increased—his services obtain a better remuneration—his personal comfort is more attended to, and his social condition generally improved; the whole community gradually participating in the advantages gained.

Such results have universally followed the introduction of machinery, and in no department of industrial enterprise are they more prominent than in that relating to the cultivation of the soil. Limited though our field for observation may be in agriculture when compared with other industrial occupations, still we have seen enough already to induce us to form a well-grounded belief in the future; and the increasing demand for various machines and implements, so ably met by the skill and enterprise of our engineers and machinists, gives ample evidence of the advantages claimed. The present occasion will probably do much towards accelerating this object. Masses of those whose daily bread depends upon their daily exertions will visit the Exhibition; they will there see collected together machines and implements, demanded by the united wants of tillers of the soil in all parts of the kingdom, nay, of the world, and produced by the united skill of our most eminent engineers and workmen. These things, though strange-looking and incomprehensible at first to some, will, to the attentive and inquiring, be easily explained; while to the thoughtful and reflective they will lead to a more correct appreciation of the advantages they afford, and thus to a better friendship between the man and the machine than generally exists in purely rural districts. We will now commence our examination of the Class, taking the different articles exhibited under the heads before-mentioned.

Steam-Engines. (Exhibitors 1, 37, 84, 124, 128, 142, 149, 182, 233, 259, 271, 242).—To commence with steam-engines, which we see exhibited both as moveable, or stationary, or fixed. Of the former there are several by our most esteemed makers. Several of these have already received prizes from the Royal Agricultural Society, and from local societies. No. 1 (Stanley) exhibits a small fixed engine to which are attached the machines mostly in use on a farm establishment, to which a thrashing machine could also be added. Another fixed engine of good workmanship and of economical arrangement may also be seen in 242. It has an oscillating cylinder and is enabled to work the crank by direct action. Room is thus saved; and by its simplicity it is less liable to get out of order than more complex machines.

The moveable engines are all mounted on travelling wheels, and present many points of observation, inasmuch as they are all different in construction. Penn's patent (124) shows a new arrangement of the piston and cylinder. The steam and eduction pipes are in copper, in order to prevent the chance of injury to the valves by the scales, or oxidised surface of iron pipes, being carried into the valves by the pressure of the steam. The boiler, and indeed the whole engine, may be regarded as a model of workmanship and finish; it is carried on springs.

Excellent engines are also exhibited by Barrett and Exall (128); by Garrett and Sons (142); by Hensman and Sons (149), and by Turner (182). In this latter we find a small supply cistern in which the water is kept at a considerable temperature, thus economising fuel and enabling the engine-driver to keep up a more regular pressure. No. 195 is Lord Willoughby's engine, of which we shall have to speak in another division on ploughs. No. 233 (Hornsby's) is well adapted to fulfil the conditions required in portable engines. It is simple in construction; its working parts are well made; it is light in draught, and being covered with a non-conducting material, it suffers less from radia-

tion than some of the others. Clayton and Shuttleworth (242) exhibit a portable engine; the prizes it has received bear good testimony to its practical value.

No. 271 (Tuxford and Sons) differs from the others, by having all its working parts enclosed. They are thus protected to a great extent from the grit and dust inseparable from barn work, from the action of the weather, and also from the chance of any unfair or careless treatment from those having the care of them.

The principal points to be sought for in a steam-engine are, that its effective power shall bear as high a relation as possible to its absolute power; (simplicity of construction by reducing unnecessary friction gives this); that the fullest effect shall be given to the combustion of the fuel used, so that the largest amount of power may be obtained, the largest quantity of water evaporated: this is done by surrounding the fire with the boiler, by increasing the heating surface by means of placing tubes through the boiler, and by coating its exterior with felt or wood to prevent loss of heat by radiation; that the strength of all its parts should harmonise; that they should be easily accessible for the purpose of cleaning or repairing, and that the engine should be made as light as possible consistent with a due regard to strength and durability.

These engines are all on the non-condensing or high-pressure system. The boilers are tubular, similar to the railway locomotives, mounted on four wheels, and not too heavy for the draught of two horses.

Thrashing Machines. (Exhibitors 29, 30, 124, 128, 135 142, 149, 154, 200, 233, 241, 242, 248, 256, 272.)—Of these there are several exhibited by different makers. In all, the principle of action is the same, the grain being separated from the straw by being brought into contact with the drum, which is driven by means of multiplying wheels at the high velocity of from 500 to 1,000 revolutions in a minute. This drum is in form cylindrical, either whole or in skeleton, to which are affixed on its external surface a

certain number (usually four or five) of projecting bars, termed beaters, running parallel with its axis. For the purpose of steadying and regulating the supply to the machine, a pair of feeding rollers are attached, between which all the corn passes to the drum: the grain is then separated from the straw, the one falling through on the floor, and the other being delivered out at the other side of the machine. To most of these machines, straw shakers are attached—a valuable addition to farm machinery, as in ordinary cases a considerable percentage of grain was carried out mixed up in the straw. These shakers are in general in the shape of parallel bars or plates (perforated to allow the grain to pass through), the alternate ones rising and falling with an eccentric motion, so that the straw may have a vertical movement given to it to displace any grain, and a horizontal movement which carries it along the length of the shaker, and delivers it at the extreme end. The bars or plates are of various shapes and sizes, and are fitted with various kinds of screws and teeth. No. 126 (Robinson) differs from all the others; it consists of a series of wooden plates about four inches broad, made to revolve separately in one direction, by means of small wheels at both ends. Most of the thrashing machines exhibited are well known to the agricultural public as having been used in different districts to a very considerable extent of late years. At the meetings of the Royal Agricultural Society, their relative merits have been tested; and as these trials are conducted with great care, the results enable us to form a fair estimate of their respective capabilities.

These elaborated trials are of great value, as they give us the means of judging how far each machine is capable of fulfilling the different conditions required of it. There are other points which affect their value, such as cost price, strength, and durability, facility of transport, convenience of arrangement, compactness, &c., which are open to the observation of every intending purchaser.

MAKERS' NAMES.	Nominal Horse-Power.	Speed of Horses in Miles per Hour.	Revolution of Horse-wheel per Minute.	Revolution of Drum per Minute.	Horse-Power required to drive the Machine itself.	Time of Thrashing 100 Sheaves of Wheat.	Horse-Power required to Work the Machine.	Horse-Power that would be required to Thrash 100 Sheaves in one Minute.	20 supposed to represent Perfect Work.			Total Numerical Estimate of Excellence of Work.
									Clean Thrashed.	State of Straw.	Broken Corn.	
Garrett & Son	4	1·87	2·439	712	1·39	3·18	6·34	20·92	20	20	16	56
Crosskill . .	4	2·31	2·700	840	·83	3·16	5·12	16·72	19	19	18	56
Hensman and Son . . .	4	2·05	2·39	1,000	1·39	3·1	4·73	14·26	19	20	20	59
Hornsby . .	4	2·47	2·89	900	2·81	2·50	8·61	24·29	20	19	17	56
Holmes . .	..	2·21	2·583	1,020	..	2·6	7·16	15·03	15	19	20	54
Barrett, Exall, & Co. . .	4	2·42	2·832	1,000	..	3·13½	6·21	20·02	20	19	17	56
Clayton and Shuttleworth	..	1·91	2·229	950	..	5·40	6·36	36·04	19	20	16	55

In No. 30 (*Anti-attrition* Thrashing Machine), we see the principle of friction-wheels applied to the axle of the drum. If these will stand the work of the drum when driven at high velocities, and keep it true to its bearing, they appear likely to materially diminish the friction, and consequently the power necessary to drive it. No. 37 (Burrell), No. 124 (Ransome), No. 128 (Barrett and Exall), No. 135 (Crosskill), No. 142 (Garrett), are all well-finished machines. Nos. 37 and 128 are whole drums; they both have an easy arrangement for regulating the concaves or aprons; and 128 has the advantage of being made entirely of iron, which gives it greater rigidity, although with only a trifling addition to its weight: the ribs of the concaves also have smoothed serrated edges, which are very material in the clean separation of the grain from the ear. No. 149 (Hensman's Vandyke thrashing-machine) differs somewhat in construction from the others, as instead of having plain beaters on the drum, they are serrated on their outer edge, the ribs of the concaves or apron being made in a circular form. By this arrangement they are said to thrash more perfectly, to allow a greater distance between the drum and the concaves, which considerably lessens the friction and consequent draught, and thus admits of a higher velocity being obtained, without an increase of power. Nos. 154, 200, 233, 241, 242, 248, 256, and 272, offer but few points for particular notice. In 154 and 233, the drum is entirely open, with round beaters. 241 has an arrangement for regulating the concave with great nicety and in an easy manner, with a generally good arrangement of its parts. In 248 the drum is worked differently from that method in most of the English machinery. It beats upwards, and has beaters three inches deep. The apron or concave has a ready adjustment. A set of fanners or winnowers is attached to the top of the machine, to which the corn has to be lifted—an expenditure of power generally avoided. In No. 272 (Plenty), the machine is fixed on its own travelling-carriage, the horse being attached.

We have been thus particular in enumerating the thrashing-machines exhibited, on account of the very prominent place they occupy in the economy of agriculture, and the important bearing which they have on the general morals of the country. The flail, its immediate predecessor, was no doubt capable of separating the grain from the straw as effectually as the best machine, but at a very much greater expenditure, both of time and labour. But the disadvantages attending its use are not confined to the mere loss of time and labour. Although the operation can be efficiently performed, still it requires the constant supervision of the employer to secure it, and this is always irksome, and frequently interferes with other, perhaps more urgent, requirements on other parts of his farm. In thrashing with the flail, the first blow separates more corn than any subsequent one, and consequently the latter part of the operation requires much more labour to produce a given quantity than the earlier part ; hence arises a great inducement to the labourer to throw the straw aside, while thus imperfectly thrashed, in order that he may have a greater bulk in a given time. Constant inspection may, to a certain extent, remedy this ; but no attention will altogether suffice to remove the temptation to dishonesty, which is continually presented to a poor man when he is left alone, and in charge of a large quantity of grain for days and weeks together ; and hence arises, even when undetected, and often indeed when not committed, a cause of great temptation on the one hand, and of injurious suspicion on the other ; both, or either, sufficient to disturb that good feeling which ought to exist between the labourer and the employer. When unfortunately the temptation has been too strong to be resisted, and the barrier of honesty has been once passed undetected, we fear much that the moral perceptions of the labourer would be too feeble to enable him to withstand other opportunities that might from time to time present themselves, for benefiting himself in a like manner. If

view the question solely in a money point, the advantages the machine offers above the flail are so palpable and evident, as at once to account for its now universal use in all well-farmed districts. The machines exhibited are each calculated to thrash from 20 to 50 quarters of wheat per day; thus representing the united strength of from 30 to 80 good men. The farmer can avail himself of any rise in the market without the loss and cost of storing his corn—a saving of barn-room and of labour in shifting is effected; and it frequently gives an opportunity for profitable employment to all the strength of the farm, at times when from frost or wet it cannot be employed on the land. If we follow out the details of the new modes a little further, we shall more readily recognise the important advantages which the introduction of machinery has conferred on the farmer, and in no case, perhaps, is it more strongly marked than in this. Let us take it, in reference to *wheat* alone, as being the most important crop, though not equalling in extent the areas occupied by the other barn crops, barley, oats, beans, &c.

The average breadth sown is about 10,000,000 (to 12,000,000) acres; the average yield we will take at three quarters (these are both minimum quantities). It is universally admitted that machine-thrashed corn yields 5 per cent. more grain than that thrashed by hand; therefore, on the mere increase alone, we should gain 1,500,000 quarters, which, at 40*s.* would amount to 3,000,000*l.* per annum. Then calculating the difference between the expenses of the two methods, taking the hand-thrashed at 3*s.* per quarter, and the machine at 1*s.*, we should find that a saving in labour would be effected equal in amount to 3,000,000*l.* more; in all, 6,000,000*l.* This sum saved, places an immense capital in the hands of the occupier to be expended on other improvements, which would react again on the quantity produced, and thus continually add to his resources. Although the flail is the only implement for separating the corn that has been transmitted to us from

the earlier ages, still we have records, both in sacred and classical history, of implements and machines in use for the same purpose. In the Bible there are several passages having reference to them. In the agriculture of the Greeks, the pages of Homer make them known to us, while the frequent mention, by Varro and others, of the "tribulum," the "plostellum pœnicum," &c., show that the Romans, as they advanced in agriculture, made use of machines in place of human labour. Though some slight advances were made in succeeding ages, the greatest step towards our present thrashing-machine was made between fifty and sixty years ago (1786), by Meikle of Tyningham, in East Lothian, whose attention was drawn to it by a neighbouring proprietor, Sir F. Kinloch, who had constructed a machine for thrashing corn (1779), which, however, for want of a proper harmony and arrangements of its parts, would not stand the work required of it, and would, like others which preceded it, have fallen into disuse and oblivion, had not the intelligence of Meikle detected its defects, which his practical acquaintance with the subject enabled him to remedy and improve upon.

This machine (Meikle's) appears to have been the form by which all subsequent machines have been made; and hence, by common consent, the honour of its introduction has been conceded to him. Various practical alterations have, from time to time, suggested themselves, and have been generally seized upon by the different makers; their results are now before the public, ready to be tested, and have their respective values assigned to them.

In all these machines it will be noticed that the beaters are of iron: those driven at high velocities have a certain tendency to break or bruise the grain which comes in contact with them, and thus have in some districts created a disinclination in the market, especially by maltsters, to purchase grain thrashed by machine. By having the beaters in wood, backed by iron plates to give rigidity, the difference between the relative hardness of the grain

and of the beaters is considerably lessened, the work is done quite as efficiently, and the corn has less chance of being injured. We have practically tested the alteration to a considerable extent, for three harvests, and have found the market sample considerably improved by it.

Winnowers. (Exhibitors 31, 53, 74, 87, 109, 124, 126, 135, 142, 148, 202, 233, 241, 248, 254, 270.)—Winnowing machines are exhibited in great numbers, and as they form an important appendage to a thrashing machine, much attention has been paid to them by the various makers. The principle of construction is much the same in all, the difference being seen in the arrangement of the various parts. When the thrashing machine is fixed, the winnower is usually attached underneath, so that the grain, as it is thrashed, may fall directly into it, and thus be rendered ready for the market at once. In other cases, the machine consists of a strong frame, having at the top a wide flat hopper, into which the grain is to be thrown, and from which it gradually falls on one or more riddles, which separates any loose straws, &c., that may be in it. Having passed through this riddle, it is immediately acted on by a powerful blast or current of air generated by fans or wings made to revolve (by means of a handle and multiplying wheels) at a great velocity, by which all the chaff or husks and light corn are driven away from the good corn, the two latter being delivered from the machine by different spouts, while the former, owing to its lighter weight, is blown out at the other end. Arrangements are readily made for altering the quality of the samples, and also for adapting the machines to winnow any sort of grain.

Class IX.—Agricultural and Horticultural Machines and Implements. Division 2.

Cutting Machines.

Turnip-cutters. (Exhibitors 110, 124, 185, 237, 252.)—The improved system of husbandry has created a great and increasing demand for machines for cutting turnip for sheep and cattle, and also for economising the consumption of hay and straw, whether for food or for litter. Of late years the turnip-cutters of Gardner's patent have been generally preferred for sheep-feeding when small divided pieces are required: for cattle this is not so important, and others of a less expensive construction are made use of, though, by a recent improvement, the same machine, with additional knives, is made, by reversing the action, to cut slices for cattle as well as for sheep. Gardner's machines, of which there are several modifications exhibited, cut the roots by means of two-sided knives, fixed on, in step-like rows, to the outer surface of an iron cylinder, which is placed in a wooden frame, with feeding hopper, and turned on its axis by a handle. These knives, acting like so many planes, cut the roots opposed to them into thin slices, which fall through the apertures and thence into a box beneath.

In 110 (Moody's patent) the cylinder is of a conical shape, and the cutting-knives are in the shape of hemispherical scoops acting in the same way as Gardner's.

In 237 a simple form of machine seems likely to effect all that Gardner's cutter does, and at a decreased cost. The knives in this are merely projecting blades fastened to the bottom of the machine, which, by means of a double crank worked by the handle, is made to move backwards and forwards, the knives working into sockets cut in the cross-pieces, by which they are kept clear, and every slice equally

cut up. 124 is a machine for cutting up chicory preparatory to drying it.

Chaff-cutters (Exhibitors 1, 27, 78, 83, 93, 109, 113, 128, 135, 137, 150, 158, 180, 185, 205, 234, 256, 275, 276) are exhibited in great variety by different makers, some of which are intended for hand-work, and others for horse or steam power. In most cases the cutting-knives are attached to the fly-wheel, varying in number, from one to three, and also in shape: the outward curved, or scimetar knife is that most approved of, as dividing the straw by a drawing-cut, instead of the pressing-cut of the knife curved inwards. The chaff-cutters exhibited, appear likely to meet the requirements of the farmer. They all have arrangements for cutting chaff of different lengths—a matter of importance where the chaff is required for horses as well as for ruminating animals; they also enable the farmer to economise his straw by cutting it up for litter, instead of throwing it down whole. The liquid secretions are thus more readily absorbed, the animals kept cleaner and drier, and the manure far better made.

In 78 a different arrangement of the cutting-knives is seen. They have two edges, and are fixed in a frame which is moved up and down (vertically) on the face of the machine, by means of a crank worked by a handle and a fly-wheel; they cut with each motion.

In 248 the cutting-knives have serrated (saw-shaped) edges, which are kept true by a very simple and efficient method of sharpening. For cutting broken or damp straw or hay they are very good, as the rough edges of the knives ensure a readier hold on the substance presented to them.

In all cases it is desirable that the knives should be so arranged as to effect a continuous cut, in order that the resistance may be kept equal. In cases where one knife finishes before the other begins its cut, the rotatory motion is increased during the interval by the absence of resistance: this being again checked occasions a lateral vibratory action, more or less according to the speed at

which it is driven, which must be prejudicial to the knives as well as to other parts of the machine.

These observations are not intended for machines worked by the hand; in these a portion of the power must be sacrificed in order to obtain momentum, while the comparatively slow speeds at which they are worked render the lateral action of no importance.

There are two machines for cutting straw only (109 and 150). The former is similar to the other machines, but has only one knife: samples of the different lengths cut are shown. In the latter, the upper roller has a number of knives arranged longitudinally on its surface, which cut by pressure on the lower roller, the straw being forced out between them.

Corn and Grass Cutting Machines. (Exhibitors 60, 81, 89, 139, 142, 145.)—We now come to a description of cutting machines of which but very little is at present known in practice, though, from the number of models exhibited by different persons, it would appear that considerable attention was being paid to the subject. A machine that will efficiently represent hand-labour in the harvest-field would be a great boon to the farmer, as in all field operations, despatch, in such a climate as ours, is a matter of great importance; and the last process of maturation is so rapid, that it rarely happens that a farmer can obtain strength enough to cut all his crops at the precise time he would desire, without taking it from other operations which are perhaps of equal importance, especially in a changeable season. These machines, however, are not new. Some 50 years ago, a reaping machine was invented by a Mr. Boyce, for which a patent was granted. It appears to have been a frame carried on two wheels *fixed on* a centre axle: this axle revolving with the wheels gave motion, by means of a pair of bevilled wheels, to a vertical axis projecting *before* the carrying wheels, to the bottom of which scythes were fastened: these revolving at a rapid rate, cut down the opposing corn; but no

arrangement seems to have been made for collecting it or laying it in swathes. Another machine, by a Mr. Plucknett, next appeared. This had a circular steel-plate or disc, with a saw-edge, which was driven in the same manner, and was considered to do better work. Mr. Gladstone, of Castle Douglas, Kirkcudbright, shortly afterwards introduced some improvements in the arrangements of the machine, in the shape of a circular table with stout wooden teeth, notched below all round, which was fixed immediately over the cutter and parallel to it. This circular rake held up the corn against the cutting-knife, and then collected it, and laid it on the ground between the wheels in two parallel lines. A small wooden wheel was attached at the back part of the cutting-knife, with which it was in contact; this was covered with emery, and thus always kept the edge sharp. The next attempt was upon quite a different principle; as in this machine, invented by Mr. Salmon, of Woburn, Bedfordshire, the corn was cut by means of shears, with an arrangement attached for collecting the corn and laying it down in rows. About this time the attention of Mr. Smith, of Deanston, was called to the subject, and the result was shortly seen in the shape of a machine, which he tried for the first time in the harvest of 1811. This was on a small scale. The succeeding harvests enabled him to notice and to remedy some of its defects, by which he was induced to have one constructed on a larger scale, which was practically used on his farm. This machine consisted of an axle and two carrying-wheels, in front of which was suspended a hollow drum or cylinder, to which a rapid rotatory movement was communicated when the machine was in motion. The lower edge of the drum was armed with a circular cutting-knife, and the cut corn was laid in a row on either side of the machine. Behind the axle was fixed a pole, to which the horses were attached, the machine being pushed forward by them through the standing corn. About a Scotch acre (five roods) an hour was cut by this

machine.* In the Highland Society's Journal is an account of a more recent machine, the invention of Mr. Patrick Bell, and which was tried at Gowrie in 1829. The work done was considered quite satisfactory: wheat, beans, and oats are said to have been cut down on uneven ground at the rate of one acre per hour.

We have been thus particular in noting the machines that have been already before the public, as most of those now exhibited seem to be merely modifications of the same construction. In 81 we see an arrangement similar to that of Mr. Boyce, motion being communicated from the carrying-wheels to a centre axis, to which two scythes, like knives, are attached. Like the original, also, no arrangement is made for laying up the cut corn; and 145 is somewhat similar. Here we have the cutting-knives of a different shape, and four in number: they are attached to arms to which a rotary movement is communicated, and have an ingenious contrivance for keeping their cutting surfaces always to the standing corn. In this machine, however, a portion of the frame (which is triangular), with a wheel travelling in front, precedes the cutting-knives, and thus would appear likely to impede the machine by pressing down the corn in front of the cutting-knives. In 190 a machine is seen resembling in principle those of Plucknett, Gladstone, and Smith. In this, however, there are two cylinders of smaller diameter, and worked in the same line; but it appears not to have any arrangement for collecting the cut corn. It is propelled by horses, attached to a pole or shafts at the back. Garrett (142) exhibits a machine constructed on the same form as those in use in the United States and in Canada. The principle seems to resemble very much that originally introduced by Mr. Salmon, of Woburn, Bedfordshire. This machine, which has the reputation of practical performance in the field, con-

* In the harvest of 1838 we had an opportunity of seeing this machine at work on a crop of oats, apparently in a very effective manner.

sists of a flat tray (sheet-iron, on a wooden frame), carried some four inches above the ground. On the front line are a series of projecting teeth which are fixed; between these, a series of teeth-shaped knives, with double-cutting edges, are made to work to and fro horizontally with great rapidity, the motion being communicated from the carriage, from the side of which this is projected. The horses walk by the side of the standing corn, dragging the machine up against it. The straw is held between the fixed teeth, and thus cut by the action of the knives: it then falls on to the tray, on which a light turn-furrow is fixed; this lays the cut corn in an even line, which is left behind as the machine travels on. There are, however, two machines exhibited which appear to be of a more novel construction. One (89) consists of two very long cutting blades fixed horizontally to a light framework, and suspended from two high carrying-wheels; these knives are joined together at one end, so as to form two sides of a triangle. The horse is attached to shafts placed behind the axle, and between the knives at the wide end, and thus propels the machine forward; a seat placed over the axle enabling the driver to direct the horse, and also to elevate or depress the cut of the machine, and it has an arrangement for laying the corn in swathe.

In 139 an attempt is made to imitate the common action of mowing with a scythe. It consists of a small square frame on four wheels, containing a transom-plate, to which an ordinary scythe, with cradle, is attached by means of light iron bars representing the handle. An upright spindle passes from the transom-plate through the top of the box, to which a cross-handle is fixed. By means of this handle, the transom-plate and the scythe connected with it are moved through half a circle: by reversing the action of the handle, the scythe is drawn back again, and its backward motion, by means of a small rack and pinion which are fixed on the axle, causes the machine itself to move forward 12 inches, or any given distance.

The cut corn is laid in swathes by the cradle, as in ordinary mowing. This machine is said to cut a sheaf at each stroke; however, as the stroke is only 6 feet wide and 1 foot deep, it can only cut down the crop growing on 6 square feet of surface. This quantity, except in an extraordinary case, would only furnish a very small sheaf. In 60 (Beckford & Gosling), a machine is seen for the combined purposes of cutting and of tedding grass. The two parts are fixed on the same axle, and work in parallel lines. The cutting portion is similar to the drum-reaping machines, and the other is the same as the tedding machines in ordinary use.

These machines are all the result of a very laudable and ingenious endeavour, by different individuals, to construct an implement that would add so materially to a farmer's powers. Some of them seem to fulfil more of the conditions required than the others do; but none of them appear to be at present capable of meeting those difficulties which present themselves to a greater or less degree on most farms, such as unevenness of surface, laid crops, &c.

Crushing Machines. (Exhibitors 1, 3, 7, 75, 77, 82, 124, 127, 128, 142, 181, 182, 233, 240, 266.)—Machines for crushing oil-cake, corn, beans, and linseed, are now in general use in most farm establishments. There are many very excellent ones for either purpose exhibited. Those for oil-cake require great strength, and are usually made with two parallel rollers, armed with spikes or teeth of a pyramidal (cams) or curved form, fixed in a strong frame, set in motion by means of cogged wheels and a fly or driving wheel, to which the handle is attached. The distance between the rollers can be regulated so that the cake may be crushed either for sheep or cattle. Crushers of this description may be seen in Nos. 124 (Ransome), 127 (Wedlake), 128 (Barrett), 142 (Garrett), 233 (Hornsby).

The crushers for grain and linseed are somewhat different, the rollers being either fluted or quite plain; for beans they are generally fluted. They vary in form, and

also in the method of regulating the rollers. In some, also, we find only *one roller* working against either one or two fixed plates in front or behind, which are grooved or fluted like the roller. The advantages resulting from the use of these machines, in the preparation of artificial food for cattle, are of great importance, as not only does the food afford greater nourishment, owing to its divided state and more assimilable condition, but the crushed state of the grain prevents germination, should any of it become mixed with the litter either by accident or by the excretions of the non-ruminating animals, which is too often seen when the whole grain is used. There are also some machines exhibited for crushing Gorse, and thus rendering it fit for cattle-food. These are well worthy of notice as materially conducing to the use of an indigenous plant, growing luxuriantly on soils which otherwise would be entirely unproductive, and yet containing in itself matter of a highly-nutritious character, and, when prepared by these machines, readily eaten by sheep and cattle.

Tile Machines. (Exhibitors 47, 98, 137, 288, 239.)—The machines for making tiles are of all of them well known to the public, and have been favourably noticed by different Agricultural Societies. The principle is similar in all:—The clay, having been previously prepared, is placed in a box, whence it is forced out through apertures or dies of different forms, according to the purposes required. The arrangement of the component parts, and the method of working them, appear to be the points constituting the difference between the various machines. In none of these do we notice any arrangement for connecting one pipe with another—a matter of great importance where pipes of small diameter are used, especially on soft bottoms. The only method at present in use is either to have notches (cut by the machine) in the end of the pipes, in which small slips of wood (dowels) are inserted as the pipes are laid; or else to have collars wide enough to carry the ends of the pipes, and thus prevent their dis-

placement. These collars are usually merely sections of larger pipes cut off by the machine in convenient lengths. A patent was taken out some three or four years since by the late Mr. Smith, of Deanston, for dividing the pipes by an irregular cut, giving them serrated instead of straight ends. By this plan the extra expense of the dowels and the collars was saved: the pipes having a bearing on each other were less liable to be displaced, and the ends being irregular, a greater drainage-aperture was obtained.

Harrows. (Exhibitors 109, 128, 135, 151, 185, 240.)—One of the first and principal conditions in farming, as in gardening, is to obtain as fine a tilth as possible. This condition is desirable during the whole period of cultivation, but more immediately of importance during its earliest stages. The implement that the farmer chiefly relies upon to effect this end is the harrow; and therefore it is natural that this important implement, so universally used, should be regarded with great attention both by him and by the machine-maker, so that the skill of the one may carry out those alterations which the practice of the other may from time to time enable him to suggest for its improvement. Unlike those machines of modern invention of which we have just spoken, the history of the harrow would probably take date with that of the plough. In the pages of the Bible we find mention made of it, and in the works of the Roman writers on agriculture we find copious descriptions of the different kinds of harrows then in use* descriptions which comprise all the various sorts of modern times, and resemble those very closely still in use in some of our backward districts. In the middle ages,

* There were four distinct implements for pulverizing the surface in use in Roman agriculture, to which the names "Irpex," "Crates," "Rastrum," and "Sarculum," were given. The "Irpex" was very strongly constructed more like our large drag harrows. The "Crates," which was made of a different weight and strength, to suit the purpose required, more resembled our ordinary harrows. The "Rastrum" had a single row of teeth like our rakes, and the "Sarculum" was, no doubt, the original of our present hoes.

while agriculture declined, the good Roman harrows were forgotten, and a more primitive substitute was used, as we find from Gervase Markham ("Farewell to Husbandry," published 1668) directions for the manufacture of the harrows, of which he gives an engraving. He says, "get a pretty big whitethorn-tree, which we call the hawthorn-tree, and make sure that it be wonderfully thick, bushy, and rough-grown." This kind of implement may be seen in India even at the present time, the native cultivators hardly using any other. In Russia (Asiatic) the peasants make rough harrows from the branches of the fir-tree, leaving their partially-removed spurs to serve as teeth. The joining together of wooden frames, as in the Belgian harrows, was a later improvement. Then came the insertion of wooden teeth: these were next replaced by iron teeth in wooden frames; and lastly, as agriculture has advanced, we have seen the old wooden frame laid aside, and the introduction of an implement of improved shape, greater durability, and more effective in the field, constructed entirely of iron. The improvement in shape consists in the parallel bars of the frame crossing each other at oblique angles instead of at right angles, as the ordinary form; thus allowing of a straight draught or traction being applied to them, and insuring a more regular division of the soil by the projecting teeth. The greater durability is obvious from the nature of the materials used. The more effective performance in the field has been proved by experiments between the work done by wooden and by iron harrows under precisely the same conditions, which have also proved that, for general purposes, the teeth or tines should be set perfectly straight in the frame, and that the best shape for the teeth is that in which the horizontal section above the pointed end is either a square or a parallelogram. These forms are considered best adapted for lessening the friction to which the teeth are subjected in being drawn in a direction parallel with their diagonals, and for resisting the

lateral strain or motion occasioned by the various obstacles with which they are brought in contact. In No. 185 (Samuelson) may be noticed the harrows in use in certain districts previous to the introduction of the iron harrows; and at No. 109 (Cottam) we may see exhibited a chain or web harrow, introduced by the late Mr. Smith of Deanston. This differs materially from the harrows just described, and is adapted more particularly for the lighter description of soils, or for special occasions. The framework of the ordinary harrow is here represented by a web or network of stout iron wire, and the teeth by iron discs, with serrated edges, and with holes in their centres sufficiently large to enable them to revolve freely round the portion of the web on the angle of each mesh or square of which they are fixed. All these harrows are made light or heavy according to the purposes required, and they are worked in sets or gangs of two or three—the whippletree or draught-bar to which they are attached having an arrangement for regulating the draught. Another form of implement should here be noticed, inasmuch as it is known under the name of Norwegian harrow, though its form and its application would entitle it rather to be considered as a clod-crusher or breaker. It was introduced into this country about ten years ago, since which it has been improved in its working capabilities, and is now generally considered as a very effective implement in pulverizing the surface soil, its peculiar form enabling it to penetrate and break down the lumps or clods without that amount of pressure so objectionable in common rollers. There are only two exhibited, 128 and 135; in both the same arrangement of tines or rowels may be noticed—the three parallel axles each carrying rowels with a different number of spikes or teeth, the first having five, the second six, and the third seven. This arrangement causes them to rotate irregularly, and thus prevents them, to a great extent, from being clogged up while working on the field. They are applied very beneficially upon ploughed

leys in the autumn preparatory to wheat-sowing, their long teeth breaking through the fibrous tenacity of the furrow slice, and leaving a finely-divided seed-bed on the surface. They are made entirely of iron, and have travelling wheels and an arrangement for guiding and for raising or lowering the implement when at work.

Rakes and Hoes. (Exhibitors 142, 151, 234, 240, 241.)—The common hand-rakes and hoes, although valuable implements in certain cases, have been found unequal to meet the requirements of modern farming, and machines have been constructed by which the combined powers of several rakes or hoes, as the case may be, have been concentrated in one machine, to which motion is given by substituting horse for manual labour. The rakes are made either of wood and iron, or of iron alone, and consist of a series of curved tines or teeth working independently (so as to suit unequal surfaces), but attached to the same bar or frame, which is carried on two small wheels. The peculiar curved form of the tines enables them, when in motion, to ride on the surface of the soil, and thus collect any substances that may be lying loose on it, a simple lever arrangement, giving the attendant who follows every facility for clearing them whenever necessary. The horse-hoes are more varied in form, some of them being intended merely for hoeing in between single rows or drills of beans or root-crops; others again, being of a wider make, and intended more particularly for crops drilled at closer distances, such as wheat, &c. These last are not, however, in such general use as the former, but are to be met with in most well-farmed districts, especially where the drilling of the crops is attended to. Of those now exhibited, 142 appears to take precedence, as being one of the most valuable and effective implements yet brought out, and consists of a pair of wheels and an axle, from which are suspended a set of levers (like those of the drill), having hoes (of different shapes, as may be required) attached, working independ-

ently of each other, and capable of being set at any desired depth by means of regulating keys; so that, however uneven the surface of the ground may be, all the weeds growing on it are sure to be cut up. A swing steerage, acting upon all the levers, gives perfect command over the line of the hoes, thus any irregularity in the drills may readily be followed without any chance of injuring the plant. The hoes may be varied in distances so as to suit the different widths of the drills, and a simple arrangement exists for raising the whole of the levers at once, when required for clearing the hoes or in turning. On the fore-part of the carriage is fixed a box, similar to the broad-cast-barrow, for sowing small seeds, the spindle being worked by a pulley and strap from the large wheels. The spouts are brought down to the ground, and have flat wide mouths, so that the seeds may be well scattered between the drills; the hoes then follow, and by paring the surface prepare a sufficient seed-bed for them. By having the horse-hoe the same width as the drill, all the driver has to do is to keep the wheel in the track made by the wheel of the drill; then if the hoes are set at the same distances, they will follow in the same lines. The difficulty of getting wheat *properly* hand-hoed in the spring is very great, the wetness of the soil and the variation in the weather generally causing the operation to be delayed until a time when other work on the farm requires attention, and yet the advanced state of the plant will not admit of further delay. The work, too, is rarely done to the farmer's satisfaction, being commonly piece-work given to strangers, whose object is to get over the ground as quickly as possible; and thus a considerable portion of the surface is frequently untouched, and merely covered up with the loosened soil. The horse-hoe relieves the farmer from his anxiety. With one horse, a boy to lead, and a man to attend to it, from 10 to 15 acres may be finished in a day, with a certainty that every part of the surface shall have been visited.

This reduces the expense of the operation from, say 3s. to about 6d. per acre; the work is better done, and the farmer is enabled to get all his crops cleared at the exact time which he thinks most desirable. In 270 may also be noticed a horse-hoe for similar purposes. It is of smaller size, and more simple in construction than Garrett's, less expensive in price, and seems well arranged in all its parts. The hoes are fixed upon two separate bars, parallel with the axle, one a little in advance of the other, a handle at the back giving the steerage to them. A seed-box is fixed before them as in the former. Two others are exhibited, 96 and 148, resembling those described in their mode of action, but containing no points needing special notice.

Horse-hoes. (Exhibitors 15, 23, 73, 124A, 127, 140, 143, 150, 185, 230.)—Of the horse-hoes for single drills we see several that deserve our attention, the increasing importance to the farmer of fallow crops having stimulated the different makers to vie with one another in providing him with the most efficient implements for carrying out the great object of the system.

We consequently have a great variety exhibited. They are all made of iron, in form resembling the handles and beams of a plough; the tines or hoes being fixed to the beam, and to the frame which is attached to it. A small wheel usually runs in front, by means of which the working depth may be regulated. In order to render them equally available in drills of different widths, they are constructed so as to expand more or less as may be desired: this movement is effected in several different ways; in 124A and 143, the required width is obtained by shifting the tines or hoes along the frame in which they are fixed. Attached to the hind part of 15, 140, and 230, may be noticed a small spiked roller, which follows and breaks up any lumps or slices left by the hoes, and in 73 a plain harrow is attached for the same purpose.

Paring Ploughs. (Exhibitors 14, 124, 185, 217, 256.)—

There are several implements exhibited for the purpose of skimming or paring the surface, especially adapted to aid the farmer in cleansing his stubbles after the crop is removed. As great strength and rigidity are required, they are constructed entirely of iron; and although they differ much in the arrangement of their parts, they all appear calculated to answer the purpose for which they are used. 124 is a well-finished implement, and is intended to be used either as a paring-plough, a scarifier, or a subsoil plough. It consists of a stout beam, frame, and sole of a plough: across the beam is fixed a shorter one, having at each end bars running parallel with the centre or main beam. Upon these bars the wheels, and also the tines or shares are fixed. If required as a paring-plough, broad V-shaped or winged shares are used; if as a scarifier these are removed, and chisel points substituted, the wheels, in each instance, regulating the depth at which it is worked. By removing the transverse beam with the side bars, wheels, &c., it is readily transformed into a skeleton-plough, and then is suited for subsoiling, for which it seems to be well adapted. 180 (Hill & Co.) is a simpler form of implement, and is only intended for one operation. It consists of an iron frame of a triangular form on three wheels, and with two stout tines, with broad angular shares or hoes, having the wings of both on the inside, so as just to cross the centre line, one being placed a little in advance of the other. A tine, with a wide chisel point, precedes them in the centre line, and two curved tines follow, one behind each share, for the purpose of breaking up the soil, and thus exposing the roots of weeds, &c., more perfectly than they otherwise would be. A lever motion regulates the depth of the tines, and also assists the action of turning in the field. 217 is a valuable addition to our list of implements, and seems to meet with and to merit the commendations of our leading agriculturists. Like 124, it can be arranged either as a broad-share plough, a scarifier, or a subsoiler, and it may be noticed as

differing from the others by having its principal working part placed at the heel of the beam instead of in front; thus rendering its action steadier and easier, the soil having been disturbed by the smaller tines or shares which precede it. The beam is long and straight, having a transverse beam at the end, made of hollow square iron, which gives rigidity without a great increase of weight. To the main beam a plough frame is fixed with moveable points and shares, and to the transverse beams are attached two cultivator tines, also with moveable points, which can be shifted along the beam, so as to work nearer or wider from the main beam as may be required. 256 is a simple skim or paring plough, with two broad paring shares, which are followed by two curved tines, having a lever arrangement (Lomax's patent), by which they may readily be withdrawn from the soil by the driver, though they are so fixed as not to shift in their work.

Cultivators. (Exhibitors 32, 34, 49, 50, 110, 124, 124B, 216, 234.)—They are all powerful implements, constructed in iron, usually in the form of an irregular pentagon, and carried on two larger travelling wheels, with a third wheel (smaller) attached to the front as a guide-wheel. They vary from each other chiefly in the form of their tines or coulters, in the manner in which they are fixed to the frame, and also in the arrangement by which they are raised or lowered while at work. In some the tines have moveable ends, so that different shares may be used according to the purpose required. In others the tines are permanent, and can only be used as cultivators. The points of difference between these machines are important, as they constitute the objects by which their relative merits are to be judged: it is, therefore, desirable, in the selection of one, to satisfy yourself that the tines are of such a form as best to withstand the strain upon them when at work, and not clog up with the weeds or other substances on the surface; that the mode of fixing them is such as neither to weaken the tine or the

frame, not to be liable to injury, nor to be difficult to alter or adjust; that the leverage for altering the gear shall be as simple as possible, and that the weight of the machine shall be as light as is consistent with the work it has to perform.

Clod-crushers—Rollers. (Exhibitors 56, 77, 129, 135, 238, 257.)—The clod-crushers of Crosskill & Co., and Cambridge, have long been in general use, and have been universally admitted to be most effective assistants in obtaining that tilth so necessary for the reception of seed, as also for consolidating the ground after the frosts of winter, or when the young plant (corn) is attacked by wireworm. These implements consist of a series of cast-iron rings freely and independently moving on an axle to which is attached a stout wooden frame with shafts for the horse. In Crosskill's, these rings have deep serrated edges, with stout spurs projecting laterally between them. In 238 (Cambridge), the rings are somewhat broader, plain on their extreme periphery, but hollowed out on either side to the depth of 1½ inches, thus giving the horizontal line a sulcated (furrowed) appearance. In 56, a land-presser is exhibited as being adapted for fen lands. This consists of a number of rings moving on a common axle, but differing from the foregoing by having their edges quite flat, and about 2 to 3 inches wide; in fact being merely sections of a common roller or cylinder. At the back is a scraper, which, by means of screws, may be fixed at any given distance. The objection to these crushers or rollers is, that they can only be used when the surface is tolerably dry, as otherwise the interstices between the rings hold the dirt, and they speedily clog up. This has led to the introduction of an improved or double roller, in which the rings are mounted on two parallel axles, and fixed at such distances from each other on the axles that those on the last shall move in lines between those on the front axle.

In this manner, one-half of the surface is acted upon by the first row, and the remaining half by the second row. The draught is but little increased, and the chance of clogging

completely obviated. The difficulty of turning these double machines at the end of the land is a great objection to their use, but this has been met by 77, on the frame of which an iron transom plate is fixed to which the horses are attached. This, by a simple arrangement, admits of the draught being applied to either side—being changed, in fact, from the front to the back of the machine; so that, on reaching the end of the land, the horses merely turn round, and the draught is applied to the back. These improved arrangements give the farmer an opportunity of using an important implement on his land at a season of the year when probably the soil would be too moist to allow of the ordinary roller or presser being used. The rollers exhibited by Warren (257) are constructed with two or more iron cylinders working on the same axle. This arrangement facilitates the turning, which is always an objection to the use of rollers formed of a single piece. In 56, a new method of fixing the scrapers may be noticed.

Hay-making or Tedding Machines. (Exhibitors 127, 128, 324.)—These very useful machines are well represented on the present occasion by 127 (Wedlake), 128 (Burnett), and 234 (Smith), in which may be noticed all those recent arrangements for facilitating and improving their work, the usual consequence and companion of an increasing demand. These machines are generally made as light as possible, having a due regard to strength; wrought iron being used wherever practicable, and a due harmony observed between the strength of the different parts. They consist of a frame, to which a pair of shafts are attached in front, and a pair of wheels and axle at the back. On this axle revolve two skeleton cylinders, to the bars or ribs of which are fixed the teeth by which the operation of spreading or tedding is effected. Motion is communicated to the cylinders by the carrying wheels, each cylinder, however, by a simple contrivance working independently of the other. The cylinders can easily be

raised or lowered, so as to suit the different kinds of work required, by means of a lever spanner acting on a pair of mitre-wheels placed at the side of the axle (in 128), or by means of a crank and screw (as in 234). The teeth or rakes are kept to their work by means of springs at the back, which enable them to yield to any obstacle in their progress, and immediately to return to their position. One man only is required to work the machine, which is very light of draught; and, by the improved arrangements, he can readily regulate its work in any way that may be required, either by raising or lowering the rakes, reversing its action, or throwing it entirely out of gear, without leaving his post or stopping the machine, while at the same time the construction is such that it is impossible for the machine itself when once set to work out of gear.

Drills. (Exhibitors 3, 35, 87, 119, 135, 142, 149, 233, 246.)—The earliest method of sowing seed was, without doubt, by dispersion from the hand, similar to the broadcast of the present day. Of this practice mention is made in the Bible, as also in the works of several of the Roman agricultural writers, where we may also find several good practical directions as to the proper mode of effecting it. We have, however, good reasons for believing that in some countries the application of a machine for sowing grain was known at a very remote period. In China, Japan, and Arabia, records exist of such machines having been in use from the earliest periods of their history. In our own country, so far back as 1638-53, Gabriel Platte ("Jewel House of Nature") describes a rude dibbling machine, formed of iron pins "made to play up and down like virginal jacks." In 1647 we are told by Harte, that a regular drill machine was presented to the Court of Spain;* and we find that Worledge, in his

* This was, no doubt, the same implement of which Evelyn speaks in such terms of commendation as having been made by a German for the Spanish Court, where it was seen by the Earl of Sandwich, our Ambassador there, who forwarded it to this country as the production of a Spaniard, named Don Leucatilla.—*Trans. Roy. Soc.*, vol. V., page 1056.

"Husbandry," published in 1669, not only advocated the use of the seed drill, but also of the drill for equally distributing manures. In 1730-40, Jethro Tull was devoting his energies to the introduction of his drill, in order that his system of horse-hoe cultivation might be fully carried out. His drills appear to have been more complicated than those which we make use of: they were constructed to sow two or more varieties of seeds at a time, depositing them at different depths; they also sowed manures, and had usually attached to them harrows for covering up the seed sown. Tull's general system of farming, however, was not very successful, and, consequently, even the good points in it suffered considerably and met with undeserved neglect, for we hear no more notices of improvements in drills until about 1782, when Sir J. Anstruther exhibited one of his invention at the West of England Agricultural Show at Bath, which he had had in constant work for the previous eight years. At that time public attention seems to have become more alive to the advantages of such machines, as several others, containing such improvements as practice from time to time suggested, speedily appeared. Although, from this slight sketch of the history of the drill, it would appear that machines for depositing seed are not a modern invention, still we must admit that the machines we see now exhibited, probably bear but little resemblance to those which preceded them in former times. There are not so many drills exhibited as might have been expected; but those now submitted to our notice, fully represent the improvements which have recently been made in their arrangements. Of these, all, except 35, appear to be modifications of the same principle, varying to a greater or lesser extent in the arrangement of the different details. They are all suitable for sowing either corn or small seeds, as turnips, &c.; and to several are attached separate boxes, from which manures can be drilled in the same manner and at the same time as the seed. 35 (Marshall) differs much from the others,

as it is of a more complicated character, and intended to sow large seed (as grain) and small seed (as grass) at the same time, finishing the work by means of the roller which travels behind, and from which the rotatory power is communicated to the sowing portion of the machine. Probably, in the field some difficulties might present themseves to this mode of arrangement. The drills exhibited, 142 and 233, merit special attention, as, by their satisfactory performance in the field, they have gained for their respective makers a high and well-merited reputation. In make, they are very much alike—their principal points of difference being in the spouts or shoots for delivering the seed, and in the arrangement of the steerage. A drill may be noticed, which is constructed to deposit seed, and also manure in a liquid form at the same time. This, for root crops, turnips, wurzel, &c., where a quick growth is desirable, is a very valuable machine, as it presents the manuring substance in a condition directly assimilable by the young plant—a matter of great importance at the particular season when such crops are usually sown.

The drop drill of Ransome, 124, seems to occupy the intermediate place between the drill and the dibble, partaking of the characteristics of both operations. In appearance it resembles the drill, and consists of a frame carried on two large wheels, and having a certain number of curved solid skim-pressers in place of the usual coulters. These work in the same manner as coulters, and are followed by the seed depositors, which act independently of them, and by a simple motion adapt themselves to any inequalities in the land. The arrangement by which the seed is deposited in certain quantities and at certain intervals, is very ingenious, and well worth notice. These may be easily regulated with great nicety; and by changing the cups the machine will sow any description of seed. Each delivery of seed is caused by a motion transmitted from the carrying wheels, so that the delivery commences

immediately the horses start, and ceases at every stoppage.

Dibbles. (Exhibitors 14, 20, 22, 57, 124, 130, 149.)—There are several machines exhibited for the purpose of dibbling seed, all of which vary much, both in principle of action and outward form, from each other. In all, the object is the same—to deposit the seeds singly or in small numbers in holes made for their reception at certain regular distances. In 20, the arrangement for dropping the seed appears to be simple, very ingenious, and effective, and the dibbles are less liable to become clogged than others of a similar form. The frame and lever arrangements for working the machine, at first glance strike you as being complicated and heavy: a little experience in the field will soon determine this point, and probably suggest the necessary alterations. Newington's, 124A, more closely resembles the foregoing than either of the others, and probably was the model on which it was constructed; the points of difference being in the manner in which the seed is dropped into the holes made by the dibbles, and the method of working the machine: one is lifted from the ground and advanced by means of the lever arrangement; the other requiring the direct agency of the workman. This is a very efficient machine, and has the recommendation of having been successfully used for several seasons, and for various crops. In 57 and 130, we see machines of a heavier and more complicated construction, requiring the same amount of horses and men to work them as the larger drills. These resemble one another in appearance and in the principle of their action, the latter being evidently an alteration or improvement on the former. They consist of a strong wooden frame carried on two wheels, having shafts attached to it. On the axle are arranged three, four, or five large hollow discs, having bosses or dibbles at certain distances on their peripheries; above the discs are fixed the small hoppers in which the seed is placed,

and which communicate with each disc, either at its centre, as in 57, or near its circumference, as in 130, from which, by an ingenious mechanical contrivance, it falls through the bosses or dibbles, which open as they touch the ground in each revolution, and close again immediately they leave it. In 130 the mechanical arrangement of the bosses is different from 57. The quantity of seed to be sown, and the depth of the dibbles, can easily be regulated, the latter are kept free from dirt by revolving scrapers of a peculiar form, which work with a rotatory motion between each. No. 22 consists of a long frame carried on wheels, from which are suspended two parallel rows of dibbles. A vertical motion is communicated to these by the wheels, their own weight in falling being sufficient to form the hole for the seed which is deposited by them, as they are lifted from the ground by the next movement. 149 is a smaller machine, and on a different principle from any of the others. In this, two plain wheels, with common bosses on their peripheries, are set in a frame carried on wheels, at the hind part of which is fixed the seed-box and drop-shoots for depositing it. As the machine moves, the bosses form holes into which the drop-shoots, following close behind, deposit the seed, which is at once covered in by a small harrow attached to the machine.

Ploughs. (The ploughs with *single* wheels, Exhibitors 55, 77, 106, 217, 256, and 257. Those with *two* wheels are 27, 124, 149, 151, 185, 230, 234, 240, 267. The *swing*-ploughs are 21, 23, 27, 49, 55, 77, 85, 91, 94, 99, 104, 107, 134, 150. The *subsoil*-ploughs 21, 42, 109, 124, 127, 128, 134, 150, 216, 224.)—The plough is, by common consent, the first and most valuable implement in agriculture, and is universally acknowledged as the symbol of tillage, receiving in some countries almost the same honours as those paid to their deities, and in all that respect and regard to which its important uses so justly entitle it. We might, therefore, fairly expect, on the present occasion, to see how far the

demands of the farmer have been met by the skill of the machinist, and whether the advancing knowledge and improved practice of the agriculturist have led to a more correct and economical application of scientific principles in arriving at the desired end. This expectation will not be disappointed; for, in looking round the collection of ploughs exhibited, we may see many which deserve particular notice, as offering points of great interest to the occupier of land; some of the principal of these we will endeavour to point out, after we have given a slight sketch of the history of the plough up to the present time. Perhaps of all the instruments used in agriculture the plough has the first claim to antiquity. In the pages of the Bible not only is it frequently referred to, but even its particular parts are specially named, and many ancient monuments in Eastern countries bear testimony to its existence and to its outward form. In these days, the plough was considered of even higher value than it is with us; and in later days, if we read the beautiful works of the Greek and Roman historians, we shall find much that will instruct us, both in the ploughs then in use and their practical application in the field; even minute points are so particularly described and explained as to give good evidence of the value they attached to the implement and its uses. The Romans introduced their agriculture into western Europe, and for some years their plough was the one in general use.* A series of improvements gradually effected a great change in its appearance, as we find in our early English writers frequent mention made of the ploughs, the construction of which is fully described, as well as directions for using them; yet our records are often very conflicting and unsatisfactory, showing, at all events, that agricultural practices were local, as in the Cotton MSS. we find a description of ploughs with wheels

* The plough, as described by Virgil, is still to be seen in use in some of the south-western provinces of France, where it bears the name of the "Araire Romain."

in front, and yet in the Harleian MSS., of later date, a rude sketch is given of one rivalling in simplicity the Hindu plough. Again, on the Bayeux tapestries (A.D. 1066), we have a record of horses drawing ploughs from their shoulders, whereas, so late as 1634, an Act passed the Irish Legislature to prevent the harnessing of horses by the tail to ploughs. Fitzherbert (A.D. 1572), and Worledge (A. D. 1677), have chapters on ploughs. The latter describes the, probably, first attempt at a subsoil-plough. He says, "An ingenious young farmer in Kent had two ploughs fastened together very firmly, by which he ploughed two furrows at once, the one *under* the other, and so he ploughed his land 12 to 14 inches deep." It appears to have been about the close of the 17th century before any great improvements were brought to bear on the implement, and those were seen chiefly in the Low Countries, whence they were brought over to this country. Blyth speaks of them, and indeed imported some from Holland, which he used for some time, and improved upon; and, in the early part of the next century (1730), we find a patent taken out for an improved plough, which, even to this day, is held in high estimation in some parts of Yorkshire and the north of England, where it is known as the Rotherham plough. Small, of Berwickshire (A.D. 1763), Wilkie, Finlayson, and other well-known agriculturists, then appear as the great improvers. These have been succeeded by other makers, who have creditably fulfilled the duty bequeathed to them, and have successfully maintained for the plough, by their skill and enterprise, the place as the first and most important of all the implements on the farm.

We cannot, in our limited space, attempt even to particularise more than the general points of difference between the numerous specimens exhibited, so that those who are interested in the subject may have some little help towards forming an opinion of their relative merits. The principal distinction between the ploughs for common purposes is

in the presence or absence of fore-wheels. The former are termed wheel-ploughs, the latter swing-ploughs. The wheel-ploughs are made either with one wheel to run upon the land, or with a second wheel (larger than the other), to run in the furrow; and as these can readily be shifted, the plough can be set to any width or depth of furrow desired.

In *Swing-ploughs* a new application is shown of a plan for reducing the friction on the sole of the plough, by means of a wheel placed at the heel (21, 55, 77). This probably would have the desired effect, if any plan could be devised for preventing the soil from adhering to it, and thus clogging it up. In the ploughs exhibited by the various makers, it is desirable to pay special attention to the form of the beam, and the mode in which the draught is applied and regulated by means of the bridle or hake attached to its extremity. The coulter and the share, their shape and method of adjustment, are important points in a plough. The mould-board, or turn-furrow, upon which the value of the plough so mainly depends, is, by common consent, still left as an undecided question; so difficult is it to devise a form that shall be applicable to all soils, or even to the varying conditions of the *same* soil. As these two descriptions of ploughs have each of them their advocates, the wheel-ploughs being chiefly used in the south, and the swing-ploughs in the north, it may be well to give a brief summary of their comparative advantages.

By the *Wheel-plough* the work generally is more easily performed, and it is done more uniformly both as to depth and width of furrow-slice, inasmuch as the wheels, when set, serve for gauges. Shallower ploughing can be effected by it—a point of importance where the soil is very thin and very stony. In some such cases a swing-plough could not be held in the ground at all.

By the *Swing-plough*, a good ploughman can adjust his furrow-slice by altering his line of draught, by means of

the plough-bridle or huke, and he can regulate it (as in crossing a furrow) by the leverage of the handles or stilts. He can thus plough across the ridges at an uniform depth, and he can work with it on almost all soils and in all weathers when ploughing can be attempted. The swing-plough is simpler in construction, cheaper in cost, and less liable to get out of order than the wheel-plough.

In the use of the wheel-plough *more judgment than skill* is required, as the whole of its working depends on the harmonious arrangements of its different parts (the wheels, draught, &c.), less depends upon the ploughman, and more upon the implement, than in the swing-plough. In that *more skill than judgment* is required by the ploughman, long practice will only make him master of it; but when once he has arrived at that point, he will probably do his work, under ordinary circumstances, better than with the wheel-plough.

There are a few ploughs exhibited with double mould-boards, for ridge-ploughing for root crops: to some a light arm or marker is attached, which can be set at any width, thus insuring parallel and equidistant lines throughout.

The *Subsoil-ploughs* are all powerful implements, and, like the common plough, vary somewhat in shape: 42, 124, 216, have four wheels, with a long straight beam, to which the subsoiler is fixed, and are made upon Read's principle; 21, 109, 224, are without wheels, and are made upon Smith of Deanston's principle; 124 is termed the Rackheath plough, and the others are modifications of some of the foregoing.

The ploughs with shifting mould-boards are termed turn-rest ploughs, and are found very serviceable in certain cases. These are 21, 28, 94, 143, 150, and 257: their forms and arrangements differ very much from each other, and require some attention from those likely to make use of them.

Some large and powerful ploughs may be noticed, for trenching. These resemble the common ploughs in shape,

the arrangement of their parts varying according to the make of the different exhibitors. (See 15, 42, 124, 150, 240.)

We may here perhaps introduce an implement exhibited by Laycock (134), which, although clearly not a plough, is intended as a substitute for it, either in trenching or subsoiling. It consists of a stout oblong frame on two wheels, with shafts before and handles behind, and carrying on its axle, in the centre, a broad iron wheel, on the external surface of which are fixed a number of long tines or teeth, slightly curved at their extremities. When at work these penetrate and displace the soil in the same manner as if it were forked, and the depth can be readily regulated.

We have now to examine another class of ploughs, which are calculated to aid much in developing the resources of the soil. Up to the present time the use of ploughs for cutting drains has been very limited, and but little encouragement has been practically offered either by the makers in the shape of improved implements, or by the agriculturists in the use of the existing ones. Those now exhibited, 198 and 214, have the advantage of having been used in their respective districts with some success. By the first one, the drain is cut to the required depth by two operations, the first plough taking out a depth of from 15 to 18 inches—the second, or finishing plough, following immediately behind it, and taking out another 12 inches, thus leaving a furrow or drain 30 inches deep. The plough has a strong coulter at the off side, firmly braced to the beam and to the share, by which one side of the drain is cut; and the mould-board acts as an inclined plane, up which the soil is forced and thrown out on the surface. The other (214) differs in construction, consisting of a strong iron frame on wheels, having the plough suspended from it. A coulter on each cuts the drain the proper shape; the soil is thrown out on the surface by the mould-board, as in No. 198; and an

arrangement exists by which the ploughman can regulate the depth of working.

Another draining plough, on an entirely new principle, was contrived about two years ago by Mr. Fowler (28A), and deserves particular attention, inasmuch as while the others merely cut out the soil for the reception of pipes or tiles, this plough finishes the *entire* operation by depositing the pipes at any given depth without even disturbing the surface soil. The machinery consists of two distinct parts—the frame to which the plough is fixed, and the capstan by which the traction is communicated to it. The plough is similar in form to the old mole-plough—a strong coulter with a plug at the bottom of it, fixed vertically in the frame, with an easy arrangement for raising or lowering it according to the depth required, or any undulations in the surface line. When commencing work the capstan is fixed at one end of the field, and the plough taken to the other, where a hole is dug of the depth of the intended drain, and the coulter and plug dropped into it. A rope is then attached to the back of the plug, on which are strung the pipes, and motion is communicated to the plough frame by a rope passing from the capstan, which is worked by two horses attached to the arms or levers in the usual manner. The arrangements for carrying out the details of the operation appear to have been carefully considered, and are readily followed, so that a large amount of work may be got over in the course of a day.*

Steam-ploughs. (Exhibitors, 123A, 195.)—We now have arrived at the last of our series of ploughs, and have to consider one of the most important of all the applications in which steam power has been rendered

* It is said to be capable of laying in a favourable soil from 6,000 to 7,000 linear feet of pipes, at a depth of 3 ft., or 4,000 to 5,000 feet, at a depth of 4 ft. An important advantage is also claimed, "that all the pipes are laid with an accuracy unequalled by any hand-work, and that, from the bottom not having been disturbed, they are never liable to be displaced by any shrinking or subsidence."

auxiliary to agriculture. 195, exhibited by Lord Willoughby de Eresby, shows us a set of ploughs worked by a stationary engine; and 123A is a model of Mr. Usher's locomotive steam-plough. Our chapter on ploughs has already exceeded its limits, or we should be much inclined to venture some opinions as to the past attempts, as well as the future means, of arriving at that great desideratum, "a steam spade."* Our past experience in the shape of *steam-ploughs* has not been satisfactory or encouraging (save negatively): our present contributions seem calculated to advance us a little on the right road. Lord Willoughby's plough has been and is still in use in a well-farmed district, and attached to it will be found a clear description of its mode of working. The engine, being moveable and separate, can be used for other purposes, and thus ought to act as a great inducement to others to take up the subject, and give the public the advantage of a more extended application, and a more practical consideration. Mr. Usher's locomotive steam-plough possesses points of great interest, inasmuch as it embraces conditions, which are considered by some of our best authorities as essential to success. It is simple in construction, and it is locomotive: the power being communicated by the engine to the revolving ploughs behind, which act as propellers to the engine; and thus the weight of the whole machine is brought to bear advantageously on its acting parts. The model exhibited has a full description attached, which clearly explains its operation.

Digging Machines. (Exhibitors 38A, 105 and 112.)—There are two machines of a novel character exhibited, Nos. 105 (Thompson) and 112 (Parsons), as digging machines; the former is an implement of large proportions, the latter only a model. The former appears as a large and very strongly

* In the "History of Agriculture," by Chandos W. Hoskyns, may be found a chapter on the Application of Steam Power to the purposes of the tillage farmer. It is elegantly and forcibly written, and will amply repay perusal by any one interested in agriculture.

constructed frame, carried on high wheels, by which the motive power is communicated to the working parts, which are arranged at the hind part of the frame. These consist of two sets of cranks, working in two parallel lines, one above the other, to which are fixed a number of iron spades: these, when in motion, are driven into the soil as in digging, and the portion separated by them is received into shoots, fixed on a separate axle, by which it is turned over and left in the track of the machine. There are many points in the construction of the machine which will, perhaps, strike the practical man as appearing very questionable: the machine, however, is said to be worked by seven horses, and then to be capable of representing the labour of 50 men. The model exhibited in No. 112 differs considerably from the foregoing: in this a series of spades or forks are attached to the hind part of the machine, and, by an ingenious and yet simple arrangement, these are made to penetrate the soil, and then, by a feathering action, to turn over the separated portion and deposit it as the machine advances. A small model, No. 38A (Murphy), is also shown of a machine, which is represented as capable of replacing several other implements; but which, from its construction, would appear very doubtful.

The common agricultural tools exhibited, 259, are believed to be improvements on those in general use. The draining tools, also, 47, 199, and 238, merit examination. In 180 may be noticed a new description of scythe which, by a simple and easy arrangement, can be rendered suitable either for mowing corn, long grass, or the finest lawns.

Churns. (Exhibitors 58, 66A, 69, 88, 92, 109, 139A, 180, 185, 202, 212, 220, 237, 263, 266, 332.)—These machines, so important in farm economy, are pretty well represented on the present occasion. They comprise specimens of most of the various descriptions of churns in general use. Of these, 66A, 69, 139A, are the old barrel churns; 109 and 202 are in metal, and immersed in a water-bath, so that the temperature (a point of great consequence) may be always

regulated. No. 220 is in metal also, and has two false ends, in which water may be poured for the same purpose. Nos. 88 and 180 differ from the others by having vertical plungers. Nos. 186, 212, 237, and 266, are square box churns: the three first have a horizontal rotatory movement; in the last the rotatory movement is vertical, and arranged in a novel manner. Many of these deserve particular attention; and as the principle of butter-making is now so well understood, a few considerations only are necessary to determine their respective values. Milk contains butter already formed, but divided into very minute particles, which are suspended in the mass of the liquid. The object of churning is so to agitate this mass of liquid, that these globular particles shall be brought into direct contact with each other, and thus assume a solid form as butter; and long practice, as well as theory, has told us that this end is obtained with more or less regularity according to the temperature at which the operation is conducted. Therefore, we have first to be satisfied as to the mechanical arrangements of a churn, and then see how far any plan may be devised for regulating the temperature of its contents.

Grinding and Crushing Mills, and Presses. (Exhibitors 23, 32, 50, 72, 77, 78, 82, 117, 124, 128, 135, 137, 142, 180, 182, 185, 242, 255, 266.)—The acknowledged advantage that results from giving corn in a ground state to feeding cattle, in preference to giving it whole, and the difficulty and inconvenience of having to send it to the mill for the purpose of having it prepared, have led to the introduction of small grinding mills adapted for the use of farm establishments (No. 135). They are mostly made with stones as in the common mills, but in some the grinding surfaces are both in steel, though varying much in construction from each other. Various other mechanical appliances may be noticed as having reference to different branches of farm economics; such as cheese-presses, and apple or cyder-presses or mills which may be seen at 23 and 77; and

others of less importance, which are readily recognised among the mass composing the collection.

Carts and Waggons. (Exhibitors 11, 13, 15, 16, 24, 28A, 94, 96, 121, 122, 127, 128, 135, 144, 150, 230, 234, and 235.) —Of those indispensable auxiliaries to a farm, there is a very large display, combining all the newest and most approved methods of construction, and illustrating, by various mechanical contrivances, the different modes for tilting or tipping, to which so much attention has lately been given. The waggons have but few representatives compared with the carts, by which one would perhaps be led to imagine that the superior advantages of the latter, in most descriptions of farm work, have become more generally appreciated than they used to be. The carts will require some attention in order to examine the different modes of arranging the draught, the tilting apparatus, and other points of interest. In 13, a revolving axle is used instead of a fixed one. In 15 and 128, the shafts are placed higher, and the bed of the cart is lower, than usual; thus giving two points of advantage—a straight line of draught, and a less height to lift the load. In 234, the tail-board has a novel arrangement; and in 121, may be noticed a simple method for securing the linchpin.

Some wheelbarrows, of a novel construction, may be observed in 29 and 36.

There are several horse wheels, or gearing, exhibited chiefly by the same makers as those exhibiting thrashing-machines. They may be seen in Nos. 124, 128, 142, 149, 154, 240, 256. Their general mode of construction is not very dissimilar, except in the case of No. 128,* which is an admirably-arranged power, and deserves particular attention by those who employ horse-power for their machinery.

Steaming Apparatus. (266.)—The general use of chaff-cutting machines, induced by the great economy of so disposing of our hay and straw, and the introduction of machines for crushing and for grinding the various

* This may be seen in motion in Class VI.

substances used for feeding purposes, in both cases aiding the animal by performing artificially the first process of feeding, have, no doubt, contributed very much towards the attempt to carry the process still further by steaming or cooking the food; thus representing, to a certain extent, the maceration which it undergoes previous to digestion and assimilation. When steam-power is used, the waste steam can, in many cases, economically be applied for this purpose; in other cases, an apparatus like those exhibited in 1, 33, 62, 116, 248, or 266, will be found very advantageous. In 33, the steam is used also for the purpose of reducing bones instead of grinding them.

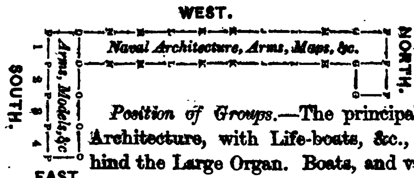
For sheep-dipping or washing, both matters of importance in many districts, there are three different apparatus exhibited, 41, 65, and 152.

The machines for weighing farm produce, either in the shape of stock (live or dead) or loaded carts, are represented by 86, 131, 180, and 266. The value of these machines to the producer is very great, as they enable him to form a far truer estimate of his operations, both as regards his cattle and his crops, than can be arrived at by the ordinary means.

There still remain many other objects worthy of observation, but which hardly call for a special notice. Those interested in any of them will readily obtain the information they may require from their respective exhibitors or makers.

Class VIII.—Naval Architecture.—Military Engineering.—Guns, Weapons, &c.

Situation of Class 8.—*The English department of this Class is situated in the Gallery at the extreme Western End, occupying the whole space from North to South, and extending round in the South Gallery from* 1 *to* 4 O. P. *Another section of the same Class will be found in the South Gallery, on the Eastern side of the Building, between Pillars* 67 *and* 70 O. P.



Position of Groups.—The principal groups of Naval Architecture, with Life-boats, &c., will be found behind the Large Organ. Boats, and various contrivances for facilitating construction, &c., at sea, on either side: It is not possible, however, to give any specific arrangement of groups.

Note.—Since the Arms which are exhibited by the different nations have their more striking characters in common, and as a constant recurrence to them in the different Sections would be objectionable, it has been thought advisable to devote an especial Section to the Arms of all Countries in the Exhibition. These will be found in the following places:—English, South-West corner of Gallery, P. 1, 2. French, J., 49. American, J, 73, M., 71. Spanish, J., 43. Portuguese, J., 44. Prussian, F., 64, J., 65, 66. Belgium, P., 55. Switzerland, L., 44. Turkey, J., 42, and North Transept. India, L., 35, 36. Jersey, J., 30.

Section I.—Naval Architecture.

Models of Ships of War. (Exhibitors 27, 36, 36a, 73, 146, 164, 186.)—In the Transept, north of Osler's Glass Fountain, is a model of H.M. ship 'Queen,' of 116 guns, on a scale of half an inch to a foot. This model shows the

difference between the form of Sir William Symonds's ship and those of the old construction. The ship is fully rigged. On the stand of this model is exhibited a piece of canvas, showing the effect of a tropical storm on the sails of a ship. On the Ground Floor, at the east end of Class V., is the model of a 12-gun brig, on a scale of two inches to the foot, presenting a peculiar scientific principle, which is supposed by the designer to insure very fast sailing, combined with good stowage for provisions, &c. At the back of the organ, at the West end of Galleries, are models of H.M. ships 'Queen' (116), 'Vanguard' (80), 'Vernon' (50), 'Pique' (40), designed by the late Surveyor of the Navy, together with a model of an old 46-gun frigate, to show the contrast between the old and new plans of constructing ships.

Against the wall, at the West end of the North Galleries, will be found sectional models, on the scale of a quarter of an inch to the foot, of a 90-gun ship, on two decks, H.M.S. 'Phaeton' (50), 'Daring' (12), 'Waterwitch' (10), and the 'Fox,' with her old and new bow. These models show the peculiarity of White's "long bow," which has proved itself to be so much superior to bows constructed on the old plan. Near these are models of a 50-gun frigate, and six models (from a line-of-battle ship to a cutter), intended to illustrate a principle advocated by Mr. White, of West Cowes, whereby all vessels intended for the same service may be built from one design. Facts, which have never been contradicted, prove this theory to be sound. The ship of the line has been found to make the finest frigate; and though every class of ship has had a separate design, it is striking to observe, if they are all brought to the same scale, how nearly they resemble each other—proving that, if, to oneness of design there be added a fixed mathematical principle of construction, the designs for the whole British navy may be contained in a nut-shell. The same exhibitor has also models of Noah's ark and a trans-atlantic steam-vessel on the same scale, in which he en-

deavours to show that the lapse of 4,000 years has done nothing to improve the proportions given by the Great Architect of the universe for a floating body that was to endure the greatest convulsions of the elements the world ever experienced.

Against the wall, at the West end of the South Galleries, are models of the experimental brigs built in 1843,—the 'Flying Fish,' by Sir William Symonds; the 'Daring,' by White of Cowes; the 'Mutine,' by Fincham; the 'Osprey,' by Blake; and 'Espiegle,' by the School of Naval Architecture. The 'Daring' proved herself, in the trials of sailing, &c. which took place, to be the superior vessel. Next to these are sectional models of first-class frigates, designed by Sir William Symonds, the School of Naval Architecture, White of Cowes, and the master shipwrights of the several dockyards. Although these vessels show great diversity of form, their superiority has not yet been decided on, the vessels proving to be so very much alike in their sailing and other qualities. Near these are sectional models of line-of-battle ships, by the same constructors, and two models of 50-gun frigates by the present Surveyor of the Navy, which are supposed to combine all the good qualities of the latest and most improved vessels of their class.

On the stand, at the West end of South Galleries, are sectional models of the bow, stern, and midship section of H.M. ships 'Queen' (116), 'Albion' (90), 'Vanguard' (80), and 'Pique' (40). These models show the interior arrangements of the fittings, armaments, &c. Two models of the sterns of first-class frigates show the advantage the new plan has over the old one for fighting the stern guns. Near these is a model of the 'Royal Sovereign' (100), built at Woolwich in 1637, the first ship ever constructed on scientific principles, and contrasted with this a model, in oak, of a Roman war galley, and one of the '*Henry Grace de Dieu*,' commonly called the 'Great Harry,' built in the reign of Henry VIII. Previously to the building of this

ship the 'Sovereign' was considered the largest in Europe. In 1512 an engagement took place off the coast of Britanny between the English and French fleets. The largest ship in the French navy, the 'Cordelier,' engaged the 'Sovereign.' They were grappled together in action, when the 'Cordelier' became enveloped in flames, which were soon communicated to the English ship. The result was that they both blew up, and the catastrophe struck the beholders with such terror that the action was suddenly terminated. In consequence of this loss, the *Henry Grace de Dieu* was built by order of Henry VIII. She is said to have cost nearly 11,000*l.*; and, as stated by Mr. Pepys, her burthen was 1,500 tons.

At the West end of the North Gallery will be found the model of a heavy-armed 12-gun cutter, made from pieces of woods taken from old and celebrated men-of-war (viz., 'Victory,' 'Temeraire,' 'Alexander, 'Captain, 'Namur,' &c.). Near these is a model of an 18-gun brig, with mechanical apparatus for the application of the catenarian curve to the lines of ships.

Screw Ships and Steamers. (Exhibitors 30, 36, 39, 41, 57, 81, 130, 135, 143, 146, 149, 163, 171, 173, 175.)—Against the wall, at the West end of the South Galleries, will be found sectional models (on the scale of a quarter of an inch to a foot) of the 'St. Jean d'Acre' (100), 'Agamemnon' (90), 'Imperieuse' (50), 'Arrogant (46): the first frigate built for auxiliary steam power, constructed in 1844, by the advice of the Right Hon. Sidney Herbert, then Secretary of the Admiralty. 'Tribune' (30), 'Cruizer' (16), 'Archer' (14), and 'Reynard' (10): these vessels are fitted with screw propellers, and so constructed that their engines, &c. do not interfere with their armament; and all that have been tried have proved themselves to be perfect men-of-war without the aid of steam power, and have answered remarkably well when working under steam and sails combined.

Lieutenant Labrousse, of the French navy, has furnished

a very admirable report on the comparative advantages of screw propulsion, from which we extract the following :—

"The use of the screw as a means of propulsion, is far from diminishing a ship's sailing qualities: it is, on the contrary, capable of adding to the certainties of navigation; and the advantages of its application to ships of the line become so incontestable, and so striking, even to persons not acquainted with steam navigation, that it seems useless to enumerate them. Let us imagine two ships together, one using the screw, and the other sails—what inequality will there not be between these two ships, one of which will be able to move about the other in all directions, with at least the common velocity of a ship (at the time and with the sails in action), without anything being able to alter her moving power, whilst the other can only move in certain directions by the help of sails, which are wholly exposed to the enemy's shot!".

The use of the screw for propelling vessels was first suggested, if not acted on, in France in 1730. The contrivance was that of M. Duguet, and its application was to draw vessels up a river against a current. In 1768, M. Pancton advocated the use of "*the pterephore*" to move boats instead of the oar. The *pterophore* being an instrument composed of a circumvolution of a helical blade about a cylinder, the radii in this blade being at right angles to the axis. In 1785, Joseph Bramah patented the screw, "for the purpose of rowing or forcing ships and other vessels in calm weather." This was followed by other patents—by Mr. Littleton, in 1794; by Mr. Shorter, in 1800; in 1815, by Trevethick, of Camborne in Cornwall, for a fixed screw propeller to work in a cylinder; and in 1816, by Millington, for a propeller similar to a smoke-jack, to be placed abaft the rudder, and to be worked by a universal joint. In 1832 Mr. Bennett Woodcroft obtained a patent for a "revolving spiral paddle," and Captain Ericson and Mr. Francis Smith patented their mode in 1836. Since that time the progress of the introduction of

the mode of screw propulsion has been rapid, and, as an auxiliary power, it is now applied in numerous ships where speed is required.

Here is also a model of H.M. steam-frigate 'Terrible,' of 600-horse power, designed by Oliver Lang of Woolwich; which vessel has proved herself to be one of the most efficient paddle-wheel war steamers of the day. Arranged here are several models of H.M. iron screw steam-vessel 'Fairy,' built by Mare of Blackwall; of the 'Jupiter,' Gravesend steamer; of the iron steam-yacht 'Peterhoff,' built for the Emperor of Russia, and a model of the paddle-box of a steamer of 600-horse power, illustrating a plan for shipping and unshipping paddle-box boats; together with models of H.M. yachts 'Victoria and Albert,' 'Fairy,' and 'Elfin,' and several other steam-vessels, which are only remarkable for the beautiful manner in which the models are executed.

On the West Wall, at the end of the South Galleries, are models of war, river, sea-going, and coasting steamers, showing the improvements made in steam-ship building since 1813; the steam-ship 'Vladimere,' built by Ditchburn for the Emperor of Russia; the steam-packet 'Wonder,' and H.M. screw steam-vessel 'Sharpshooter,' also, by the same exhibitor, the mode of a wrought-iron caisson, to supersede the entrance gates to the new docks at Woolwich.

At the same place will be seen the model of a steam-vessel for a tug or passengers, the first ever used on the Danube; the model of the 'Termagant,' screw steam-vessel, of 520 horse-power; and the 'Amphion,' auxiliary screw steam-ship, with White's bow. The model of a sailing vessel, with auxiliary screw propeller, to be worked by the men on board instead of by steam power, is curious as a return to the old patent of Shorter, who proposed to work his screw by means of a capstan. Attention should be turned to a patent canal or river steam-tug, for hauling vessels on canals, having neither paddle-wheels nor screw-

propeller, being worked with a double keel and a well or trough between the keels, which may be closed at the top or bottom, or both, to form a hollow chamber or tube inclined from the centre to the bottom at each end. Across this well at the centre are two wooden wheels, one over the other, which are driven by the steam-engine. Along the bottom of the canal or river a flexible iron band or rail is laid about $2\frac{1}{2}$ inches wide by $\frac{1}{8}$th of an inch thick: this band being raised up into the well, and laid between the two wheels, the upper wheel is screwed down, and it becomes tightly compressed between them; as these two wheels revolve the band is drawn rapidly through them from stem to stern, when it again sinks to the bottom.

Here are also models of the steam-ship 'Vassitei Tigaret,' built for the Turkish Government by White of West Cowes; the design for the first transatlantic steam-ship; a design for an ocean steam-ship of 3,000 tons, and the steam-ships 'Vectis' and 'Medina,' built for the Peninsular and Oriental Company, and for numerous other screw and steam-ships of large tonnage.

On the Stand, at the end of the North Gallery, will be found the model of an improved steam-vessel, intended by the designer to possess all the qualities desirable in a good sea-boat, and for carrying weight at an increased speed. Models of fan propellers, variously applied, and the model of an improved first-class sea-going steam-ship.

In the Foreign South Gallery is the model of a steam-vessel with some novel arrangements in propelling, &c. To the engine shaft is attached a wheel working in a water-tight case, to which water is supplied, and from which it is allowed to escape by a pipe terminated by a nozzle on either side of the ship, which by universal joints can be raised or depressed to any angle, directed backwards, forwards, or downwards, simultaneously or alternately, thereby giving a greater or less speed to the ship, or causing her to remain stationary. A model of the

stern of a vessel, with a new propeller and machinery, the object being to obtain a more direct reaction, less slip, and greater velocity of stroke; and a model of a new plan for paddle-wheels for steam-vessels by vibrating flanches.

Yachts. (Exhibitors 30, 33, 35, 36, 57, 129.)—At the end of the Galleries are several beautiful models of the 'Victoria and Albert,' 'Fairy,' and 'Elfin,' Royal yachts by different exhibitors, remarkable for the manner in which they are executed. A model of a schooner yacht in a cradle, showing a new method of launching by Mr. Peake, of Woolwich Yard. The model of a schooner yacht with storm sails. The model of a yacht, said to be the fastest ever built in Scotland. Model of the 'Laverock,' 'Constance,' and the Emperor of Russia's schooner yacht 'Queen Victoria,' built by White, of Cowes. A model of a yacht, designed by Capt. Ellis, R.N., with a sliding keel to enable her to go up shallow rivers and over bar harbours, with a method of suddenly lowering the mast to a level with the deck in a gale of wind, and a projecting bow which tends to keep the vessel up in a sea-way. Half-models of the Plymouth yachts 'Pixey,' and 'Halcyon,' exhibited for their asserted great speed and weatherly qualities, and numerous other wood and iron yachts by different exhibitors.

The models of vessels belonging to the Royal Thames Yacht Club are in a case over the staircase of the North Galleries (Pillars 8 and 9): the case contains numerous and well-finished models of wood and iron yachts, distinguished for their speed.

In the South Foreign Gallery (Pillar M. 68) is a model on a large scale of Mr. Greville's brig yacht 'Anonyma,' with spars and sails complete.

Merchant Ships. (Exhibitors 36A, 37, 56, 131, 134, 141, 153, 160, 304, 307.)—The models in this class consist of merchant ships of 2,500 tons, by White, of West Cowes; also of a ship's hull of parabolical form (37), and half-models of several of the ships of Messrs. Wigram and

Mooney. The model of a merchant frigate of 1,392 tons, belonging to Messrs. Smith of Newcastle-upon-Tyne, shewing the construction of an East India ship on the most approved form, combining great speed with ample capacity for stowage and great convenience for passengers (scale ½ inch to 1 foot), is instructive, as is that of the 'Owen Glendower,' East Indiaman, built at Blackwall, and the model of a clipper schooner, complete, and in working order. The model of one of Lindsay and Co.'s line of ships to Calcutta, of 800 tons, that of the hull of a merchant ship of 867 tons, O. M., built according to the regulations of Lloyd's, and the skeleton model of a ship, showing the mode of fastening merchant-ship's timbers; and a merchant ship, with diagonal frame timbers, of a ship with asserted improvements, and one of a merchant vessel of the first class, to rank A 1 at Lloyd's, fitted with Hughes's new windlass and steering apparatus, show the numerous improvements which have been made lately in the construction of British merchant ships, within comparatively a few years.

Life-boats. (Exhibitors 4, 5, 9, 14, 16, 17, 20, 21, 22, 23, 25, 40, 45, 46, 47, 49, 50, 51, 53, 54, 54A, 55, 60, 82, 83, 91, 100, 104, 136, 136A, 137, 138, 151, 157, 169A, 190, 197, 290, 309, 312, 322, 323, 324, 335.)—The models of life-boats exhibited are very numerous, and are distributed over the whole of this class: the most remarkable are those from the Northumberland Life-boat Committee, consisting of models of life-boats competing for the prize: these are all arranged on a stand at the back of the Great Organ at the West end of the Building. It would take too much room to enter into the peculiarities of each separate boat; but amongst the most remarkable of those exhibited will be found a patent collapsible life-boat (104), the object of which is to enable emigrant ships and all vessels carrying passengers to take to sea enough boats for any emergency without crowding the decks; it is always ready for use, *frapped to under the davits*, and projects very little from the ship's

bulwarks (not more than two feet for the largest boat ever carried): the expansion is effected instantaneously by casting off the gasketts, when the boat flies out and open at the same moment, taking a large volume of air into its fore-and-aft compartments. The advantages are stated to be immense buoyancy and stowage, greater strength in some respects than many other boats, impossibility of sinking, and they are said to possess extraordinary qualities under sail, being extremely stiff and weatherly. The general principle of insuring floatation under all circumstances, is carried out under different conditions in all; we have, therefore, only to direct attention to a few of the most novel arrangements.

The model (23) is fitted with air-tight compartments, six at each side, and one internally, all independent of each other; if capsized, she forms the same boat when turned upside down; is very swift, easy of draught, and inexpensive to construct.

The self-acting life-boat (81) is calculated to right herself immediately with the crew lashed to her thwarts, in the event of her being upset, without the assistance of any additional weight or ballast.

The model of the eclipse or standard life-boat (60), is said to possess the following recommendations: it is economically constructed, possessing in its formation great strength and durability; it is very buoyant, and frees itself instantly of all water shipped, and will keep its position upright in the heaviest sea; it is formed of diagonal battens, laid similar to that of lattice-work, and its outer sheathing is formed of gutta percha; its buoyancy is 350 cubic feet of air, capable of sustaining upwards of 9½ tons; at the stem and stern, and on each beam and quarter, is run a bow to which is attached galvanised springs, which it is thought will be found of the greatest utility in cases of collision, as it acts similarly to railway buffers.

The catamaran, or life-float (13), is composed of water-

proof canvas cylindrical cases, filled with bedding, provisions, &c., which would prove of great utility to the crew of a shipwrecked vessel.

49 is the model of a life-boat fitted with numerous cells composed of gutta percha of peculiar forms; it is not easily capsized, and when turned bodily over, rights itself immediately; it rows or sails equally well both ways, and steers with oars or rudder.

Another model (54) righting herself under all circumstances, without the aid of an iron keel or dead-weight of any kind; and one 30 feet long, 8 feet beam, and 3 feet deep, which is said to be capable of saving the lives of 300 people, and to be perfectly manageable when full of water and persons; with a third (136), which when full of water will empty itself in the short time of four seconds by means of two apertures in the bottom, merit attention for the ingenuity displayed in their construction. A small pattern life-boat, clinker built, fitted with air-tight ceiling, feathered and grooved up to her gunwales, having a well holding 44 gallons of water for ballast; and a deck-seat convertible into a life-raft, &c., should be inspected.

In this Class will also be found South Shields life-boats (Ground Floor, at the East end of Class V.), completely fitted with sails, &c.; the life-preserving apparatus of the Royal Humane Society; life-boat, and specimens of gold and silver medals, from the National Institution for the Preservation of Life from Shipwreck; patent floats, or life-preservers; grapnel shot to assist in hauling off life-boats; models of a floating buoyant settee for the deck of passenger steamers; a portable raft for the preservation of life from shipwreck; and various articles connected with life-boats and the preservation of life at sea—which well deserve strict examination and attention.

Boats. (Exhibitors 5, 146, 167, 168, 169, 185, 178.)—In the Western Main Avenue will be found a beautiful model of the state barge of the Lord Mayor of London. At the West end of the Galleries (146) are models of the Admi-

-ralty barge; boats for ships of war, from a launch to the dingy; the model of a 30-feet galley, from Richard Treginza, of Falmouth; and a model of a yacht's boat fitted with Light's patent buoyancy material. In the space on the Ground Floor, at the end of Class V., is a gunning punt, with water-tight bulk-heads, for wild-fowl shooting on the coast; and in the Foreign South Gallery, a racing-boat (167) built of mahogany and maple; a boat (168) built of wood, coated on both sides with a compound of gutta percha and India rubber; a London outrigger sculling-boat (178) for racing, the body in one plank from stem to stern; the model of an eight-oared shallop, with awnings; and the model of a contrivance for packing wager-boats.

Fishing-boats. (Exhibitors 198, 148, 316, Class VIII.; 185, Class XXIX.)—At the West end of the Galleries are models of the new Mevagissey drift and fishing boats, and of a Falmouth river barge, made by R. Treginza. In the Foreign South Galleries is the model of a St. Ives drift fishing-boat; and in Class XXIX., space at West end of Foreign North Galleries, are models of a Hastings fishing-lugger, a Peterhead herring fishing-boat, a screw propeller fishing-boat, a Deal lugger, and Cornish fishing-boats, together with models of their nets, gear, &c.

There is also in the West end of the Galleries the model of a Ramsgate lugger, used at that place to render assistance to vessels in distress; and the model of a Sunderland pilot coble, with its oars, sails, and other appointments.

From an examination of these, a very perfect idea will be obtained of the peculiarities in structure of the fishing-boats around different parts of our coast. Most of these have been adopted, after many years of severe trial, experience having indicated the best conditions for the purposes to which the boats are applied in the various localities.

Ship-building Contrivances, &c. (Exhibitors 18, 52, 85, 86, 156, 160, 165, 176, 298, 334.)

In the North Gallery is a model of Morton's patent slip

for hauling up ships for repairs, being a cheap substitute for a dry dock. Before this system was adopted, the cost of hauling up a 500-ton ship for repairs was 170*l.*; it is reduced by this plan to 3*l.* Near this is the model of a plan of Captain Sir S. Brown's for hauling up on dry land the ships in ordinary belonging to the Navy, said by him to be a better means of preserving them from dry rot, &c., than the measures at present adopted.

In the space at the West end of the Galleries is a model (298) of a proposed preservative dry dock for the Royal Navy, for laying up ships of all classes dry without dismantling them, or removing their machinery, &c.; for examining, repairing, or refitting ships; and for selecting from the reserve for commission with certainty, and with the greatest despatch and economy; also for building ships seasoned and dry, and for laying up ships in frame for seasoning.

The miscellaneous character of this section of the Class will be best seen by the following selected list:—

A model (160) of the frame of a South Sea whaling ship (scale quarter of an inch to a foot), showing the mode of fastening the beams, &c., of vessels engaged in the whale fisheries. A built model of the barque 'Ealing Grove' (165), on a scale of one-third of an inch to a foot, one side being left open to show the construction and fastenings of the interior arrangements. The model of a brigantine, fitted with Colegrave's anchor, cable, and lanyard springs. A model (18) showing the mode of fitting Rapson's slide-tiller to ships of war and merchant vessels. Models of ships, temporary rudders (156), showing also a plan for wearing a ship without a rudder. A portable ship-launching apparatus, for launching ships which have been stranded, where the ordinary mode cannot be adopted. Invented by Mr. Wark, of Waterford. White's heaving-up slips, with recent improvements.

Model of truss-work introduced by Sir Robert Seppings for the internal fastenings of ships, and on the same

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the centre, to admit the valve, which is opened or closed by means of a screw attached to it; this, being a fixture, cannot be lost, as the plugs at present too frequently are. (68.) Brass registered side-scuttles, for light and ventilation of ships, and a safety-plate to cover the aperture of a ship's scuttle (69), instead of the whole of the scuttle being covered with lead or wood, is an external plate, put on from the inside, making it a compact body of brass; is said to save the expense of the usual way of covering, by nailing, and not to injure the ship's side;—this mode lasting till the scuttle is worn out, and it makes the scuttle safe, in case of a storm, in one minute, preventing any great inrush of water. (74.) Is a model showing a proposed method of lowering a ship's boat with speed and safety, in case of accident, preventing one end of the boat going down quicker than the other; a man in the boat can lower her into the water, or raise her to the level of the deck, by pulling a single rope. We have here also a model of a plan (76) for the correct measurement of tonnage of ships, &c.; (77) and a method for reefing the paddle-wheels of steamers. (78.) A patent copper powder-barrel, is said to preserve gunpowder in perfect safety against damp or fire. Among the varieties are a marine swing table (80); a bell buoy, for warning vessels of danger (88); models (89) of a fan-propeller, variously applied; (90) Prince Albert's mirror, upon a nautical adjustment; universal rowlocks, boats, safety-reel, mast-clamp, gun-elevator, &c.; (92) improved rudder fastenings, which can be refitted on board; (98) a patent windlass to raise ships' anchors; (101) patent ships' sheathing-metal and fastenings; (103) brass urn-shaped binnacle, of entirely new construction, with newly-invented compass; and (104) a patent perpetual log, for indicating the speed and leeway of ships; (105) a bronze binnacle, with compass, designed from the 'Water-lily.' An improved ship's binnacle (106), with reflecting lamp, which can be used as a signal-light; (111) a boat binnacle, containing compass and lamp; and (113) a fog safety-light for shore

and ship signals; (120) registered marine signal-light, which yields a light equal to a blue light—are of another order of ingenious designs. (114.) A model of a windlass and capstan, fitted with Johnstone's patent double-action lever-purchase; another of a ship's capstan and rim, or cable-holder, and Gryll's patent whelps; (115) improved steering-wheel, to prevent accidents at sea; (116) model of improved ship's capstan; (117) patent pillar and screw apparatus for preventing ships from hogging, and for restoring hogged ships to their original shear. Hogging may be explained, to those unversed in nautical terms, as meaning a bending of the keel out of the straight line. (150.) The models, illustrative of the system of lightning-conductors employed in Her Majesty's ships, require some description which cannot be better given than in Sir W. Snow Harris's own words: "In order to arm a fabric effectually against the effects of lightning, the conductors ought, in the first place, to be of metal, but as metals vary greatly in their conducting power, one of the best conducting metals ought to be selected. For this purpose copper has many advantages over any other metal. In the second place, to prevent the possibility of fusion, the conductor ought to be capacious. Now it has been found that a copper rod, three-quarters of an inch in diameter, or an equal quantity of copper, under any form, is capable of resisting the heating effect of any discharge of lightning whose effects have hitherto been recorded. Thirdly, the conductor should consist of several branches, with pointed rods projecting freely into the air, from distant summits of the building, and connected by horizontal branches passing along the ridges of roofs, and from these sending off other branches to the ground. All great masses of metal occurring near the conductor should be bound up with it, and all the terminating branches should be connected with a spring of water, a drain, or some other conducting channel. In a ship, each mast should have its own capacious conductor permanently fixed and connected, with bands of

copper passing through the sides of the ship, under the deck-beams, and with large bolts leading through the keels and keelson, and including, by other connections, all the principal metallic masses employed in the construction of the hull. Under such a system, a discharge of lightning falling on a house, or a ship, finds its way to the earth or the sea, without the possibility of danger. The great principle in applying such conductor, is to place the ship or building in the same electrical condition it would assume supposing the whole were a solid mass of metal, or as nearly as may be, and the conductor should be applied, so that a discharge of lightning falling on the general mass cannot enter upon any circuit of which the conductor does not form a part." (188.) Specimens of patent marine-glue, showing its utility in naval architecture, and its durability and cleanliness, are exhibited (*end of Class V., Ground Floor*). (291.) Model of lanyard-plates, to set up the standing rigging of ships in lieu of rope lanyards and dead eyes, and of masting-shears (318), capable of lifting a boiler of 20 tons, adapted to put masts into ships, are ingenious. 327 is a new method of launching the long-boat of a merchant vessel; and in Class VII. (No. 10), the models of chain and twisted cables, and of a metal light-house, appear to complete this section.

SECTION 2.—GUNS, WEAPONS, &c., OF ALL NATIONS.

The natural instinct of man has led him in all ages and in all countries to give the highest possible degree of perfection to his weapons of offence and defence, and to lavish on them all the ornament which the state of art at the period could command; thus the skill which has been displayed in the manufacture of the arms of any people has been made one of the tests of the degree of civilization to which they have arrived. If we refer back through history, taking our own, as we might any other civilized nation, as an example, we learn that 1,800 years ago the inhabitants of this country were in a rude and barbarous

state; that they went about nearly naked, with their bodies painted and tattooed like the savage nations of the present day; their arms the club, the stone hatchet, the spear, and the bow with its flint-headed arrow, like those of the New Zealander, the Australian, or African savage.

The rude figure of the Red Indian in the *American* division of the Exhibition, with his bow and arrows and paint and tattooing, may be considered as representing man in his savage state whenever or wherever he has been found.

In the coats of mail, the helmets, the battle-axes, the spear, the sword, the cross-bow, and the matchlock of the *Indian* collection we see examples of arms similar to those used in this country 400 years ago.

Cross-bows were introduced into England in 1100, in the time of Henry I., and *archers* were embodied in the English army up to the time of Cromwell in 1650.

Gunpowder was invented at a very early period either by the Chinese or Arabians: its composition and effects were described by Friar Bacon in 1270, but it was not made in this country till the reign of Elizabeth, in 1550, before which it was imported from abroad. The best gunpowder is composed of nitre 75 parts, charcoal 15, sulphur 10—100.

Cannon, described by John Barbour as "crakys of war," were used by Edward III. at the siege of Aberdeen, in 1327, and also by him at the battle of Cressy, in 1346, but were not made in England till the reign of Henry VIII. in 1521.

Match-locks were introduced into England in 1471, by Edward IV., under the name of "hange-gunnes," and were fired from rests.

Flint-locks, or fire-locks, under the name of "Snaphaunces," were substituted for the matchlock by William III. 150 years ago, about which time all the armour used by the soldiers was sent to the Tower, excepting some helmets and cuirasses for the artillery.

The *Percussion-lock* is the invention of the present time; and although it may be said to have nearly superseded the

flint lock in this country, a vast quantity of muskets with flint locks are still made here, in Belgium, and other places, for exportation to America and Africa, and other parts of the world, many specimens of which are in the Exhibition.

The detonating powder used in the best percussion caps or tubes is composed of fulminating mercury 3 parts, chlorate of potash 5, sulphur 1, powdered glass 1—10.

Ordnance—Iron Guns and Mortars. (Exhibitors, English, Class 22, 85; Belgian 142; Prussian 677; Spanish 262; Turkey, India.)—Cast iron is, comparatively speaking, a weak substance for resisting extension, or for withstanding the explosive energy of gunpowder, its strength, as compared with that of wrought iron, being only as 1 to 5, and in consequence many attempts have been made for improving the quality of the metal, and for substituting wrought iron for cast.

In the Belgian collection there are six guns and howitzers and a mortar from the royal foundry at Liege, made of cast iron, "prepared with coke and wood," and as they were taken from the mould, without being afterwards turned in a lathe. One of these guns is said to have stood 2,116 rounds, and another 3,647 rounds, without much injury to the touchhole or vent; whilst one has been twice "rebouched," and has stood 6,002 rounds without injury. As few guns of cast iron will stand more than 800* rounds without becoming unserviceable, this mode of preparing the iron, and leaving the gun as it comes from the sand, appears to be a great improvement upon the ordinary mode of casting.

In the *Prussian* collection there is a field gun of "forged cast steel" of a very peculiar construction. To get over the difficulty of forging it with the trunnions on, the gun has been made without them, and a hollow casting with trunnions afterwards slipped over the breech and secured in its proper position by screwing in the cascable. We do

* At St. Sebastian, 2,700 rounds were fired from the English batteries, but, as was observed by an eye-witness, "You could put your fist into the touch-holes."

not know the strength of this metal, but judging from the tenacity of that in the cuirasses exhibited with the gun, it must be very great.

In the *Spanish* and *Turkish* collections we have examples of guns made of wrought iron, not from choice but necessity. The wrought-iron howitzer and mortar from Spain, were made by the Carlists in 1837, and afterwards taken by the Constitutionalists.

The *Turkish* guns are made like the twisted barrels of a fowling-piece, and were manufactured after the capture of the Turkish artillery by Ibrahim Pacha: they have gold touch-holes, and are handsomely inlaid, and well worthy of notice.

In the *Indian* collection there is an iron field gun with a very curious carriage, and also a beautifully ornamented iron rifle wall piece.

Brass ordnance are made of what is called gun-metal, composed of about 10 parts of copper and 1 of tin.

In the *Spanish* collection there is a very large brass howitzer from the Royal Foundry at Seville (263); it is nine inches in the bore.

In the *Indian* collection, there are two small field guns and a camel gun, secured to the bow of the saddle, and fired from the back of the animal, and two curious wall or camel guns on pivots.

Shells, &c. (Exhibitors, England, Class 22—85; Belgium, 142.)—One of the shells of the monster mortar, "à la Paixhain," used at the siege of Antwerp, is exhibited: it is 22 inches in diameter; the largest in the English service is only 13 inches.

Rifles, Muskets, Fowling-pieces, and Pistols. (Exhibitors, English, Class 8, 59, 200, 219, 221, 223, 234, 236, 238, 245, 251; French, 468, 1251, 1547, 1611; Belgium, 147, 151; America, 321; Switzerland, 68.)—The barrels of the inferior class of guns are made out of pieces of wrought-iron plate, which are formed into a tube on a mandril, and after being repeatedly heated and welded under the hammer, or

between rollers, are bored and turned or ground true, both inside and out.

The barrels of the best sort are made by coiling flat rods of the best iron and steel mixed together round a mandril in a close spiral, and then welding and hammering them into a perfect tube: these rods are about three-quarters of an inch wide, and are frequently made out of stubs, old horse-shoe nails, into which needles, or broken bits of files, or steel in any shape is generally introduced. Two and sometimes three of these rods, first separately twisted, and then welded together and coiled round the mandril, produce those beautiful patterns, which are known by different names, as Damascus twist, stub twist, &c. The variations of the pattern depending entirely upon the alternations of iron and steel, and the twist given to each single bar upon itself, previously to its being coiled round the mandril.

Several exhibitors have sent specimens of barrels in every stage of finish, so that the exact mode of making the twists can be seen.

Steel barrels are made of rods forged from steel containing different proportions of carbon, varying in amount from one-fourth to two-thirds per cent. Rifle barrels are made much thicker than the barrels of ordinary guns; they usually have two or more spiral grooves in them, making a whole, or half, or a quarter turn in the length of the barrel; but some increase the turn gradually from the breech to the muzzle, commencing at the rate of one turn in 6 feet and ending at the rate of one turn in 3 feet: this gives the ball a rotary motion through the air, which makes it proceed with great truth in the direction in which it is fired, whilst the close fitting of the ball secures the full force of the powder.

Mr. Lancaster, of Bond-street, has lately invented what may be called a smooth-barrelled rifle, the bore of which is slightly elliptical, and makes one half revolution in the length. In ordinary practice it requires considerable force and some time to ram down a ball in a rifle, to obviate

which *expansive balls*, having an iron plug in the end of a sugarloaf-shaped ball, have been invented, by which means the ball can be dropped into a rifle as easily as into a musket; the concussion of the explosion drives the plug into the lead, causing it to expand and fill the grooves of the rifle, or more closely to fit a smooth-barrel gun.

Telescopes are fixed on many of the rifles, with cross hairs in them: this enables the shooter to take more accurate aim. In the English collection, Captain Davidson exhibits his collection of rifles with telescopes. Similar arrangements will be found in the rifles of America, Belgium, Switzerland, and many other countries.

The best rifle will range with considerable accuracy from 1,200 to 1,500 yards: a good shot would seldom miss the top of a hat at 100 yards.

It is impossible, in a slight sketch of the arms in the Exhibition, to particularise the merits of the many very beautiful rifles, guns, and pistols in it, as our observations must be limited to peculiar and novel features of construction, rather than to elaborate finish or elegance of design; but there will be found in the French, the Jersey, the Belgian, and English collections, superbly ornamented guns, some of which are priced at 400*l*., whilst in the other extreme there are guns the price of which is 5*s*. 6*d*. each; that is, the same money which would purchase one of the highest price would buy 1,454 of the others. These low-priced guns, from the extreme cheapness with which the barrels are made, have received the name of "park paling," for which they are well suited. They are sold in vast numbers to the Brazilians, who exchange them for slaves in Africa.

In common guns the breeches are made by merely screwing flat plugs into the ends of the barrels, the touchhole being punched or drilled through the barrel; but in all other guns the breech contains a conical-shaped chamber, into which the touchhole is drilled at the side or above, or, as has recently been done, through the centre of the

breech behind. Guns, with this latter arrangement, have been patented under the name of "Central fire percussion gun." The breeching and break-off is now made in one by some makers.

Rifles, Guns, and Pistols loading at the Breech. (Exhibitors, French, 1546; Portugal, 637; Belgium, 143; Prussia, 149, 478, 678.)—The *Needle* Gun. In this gun the breech is opened by merely turning down a lever; the cartridge, with a patch of percussion-powder in the end, is then placed inside the breech, which is again closed, and the charge fired by pulling the trigger, which projects a needle against the patch at the end of the cartridge. Sugarloaf-shaped balls are fired from rifles of this construction, which are capable of killing a man at the distance of near 800 yards. Made by Geherman, Berlin.

Guns of this construction are also exhibited by Ancion, of Liege, in the Belgium collection, and by Beranger, of Paris.

Portugal exhibits a curious flint-lock gun, loading by means of two chargers for containing the ammunition, about half the length, and as large as the barrels in the bore. The barrel can be disengaged from the breech, and turned round, so as to bring the chargers over the breech for loading.

Prussia.—A rifle, loading at the breech, by Schallers, of Suhl, is very ingenious. A curious seven-barrelled rifle is also exhibited, all of which may be fired at once with needles. Rifles, loading at the breech, on the Russian system; in those from Belgium the charge is placed in a cylinder, which revolves in the breech. The lock is cocked at the same time that the charge is turned into its place. It is fired by a needle.

Fusils à la Bascule. (Exhibitors, France, 308, 1712; Belgium, 150.)—Double guns, rifles, and pistols, with a joint a little before the trigger-guard, which allows the barrels to be so far depressed as to free their ends. The charges, in brass cylinders, with patches of detonating-

powder in their ends, are then inserted, and the barrels replaced and secured by a catch.

"*Flobert*" *Rifle* (Exhibitors, France, 215, Belgium, 143), in which the pellet of lead, the charge and copper cap are all in one.

Self-loading Carbines, &c. (Exhibitors, England, 218, France, 58, 1611.)—Self-loading carbines at the breech, and other guns loading in the same manner, are introduced, and carbine and pistols, "à la Bascules," for firing pellets of lead with an ordinary common copper cap; also pistols, "à Montechristo;" the breech turns round, so as to allow the pellet of lead to be placed on one side, and a copper cap on the other; the trigger-guard, turning on a pivot carrying the breech, enables this to be done with great ease and safety.

Revolving Guns and Pistols. (Exhibitors, England, 203, 220, 222, 223, 234, 236, 237, 240, 246, 247, 260.)—In these, from 6 to 21, barrels are either made to revolve so as to bring each barrel in succession under the hammer of the lock, or they have one barrel, and a cylinder containing several chambers, which revolves, bringing each chamber in succession to the barrel, and under the hammer of the lock.

Revolving Barrels.—Of the first kind there are a great number in the Exhibition, both in the English and in the foreign collection; (1681) in the French, has a dagger projecting between the barrels; in (270) Spanish, the barrels unscrew. The English (241) have six large barrels round six smaller ones; besides the above, there are several ingenious examples of these kinds of pistols.

In the American collection (307), a self-cocking and repeating 10-barrel pistol is adjusted by the action of pulling the trigger; after each discharge the barrels revolve, bringing another under the hammer (see also 1308, France). In the Belgian collection (143) is a 21-barrelled pistol of this description.

Revolving Chambers.—In the American collection (321),

Mr. Colt exhibits a great number of pistols and carbines with revolving chambers. In these, when the hammer is down, it rests between two of the pillars, which prevents the breech from turning, and secures it from accident. At half-cock the breech is freed, and can be turned round by the finger for the facility of loading, which is very quickly done by means of a jointed ramrod, the upper part of which acts as a lever to force the lower part and the charge into the chambers. At full cock the breech is brought with a cap under the hammer, and each charge can be fired as rapidly as one can cock and pull the trigger.

Prussian.—A 12-chambered breech, by Gleichauf, of Bockenheim, near Frankfort, is on the same principle as the above; but the charge is contained in a copper cap, to which the ball and copper cap are attached, and it is fired with a needle.

In the *Belgian* collection (143), Ancion, of Liege, exhibits a six-chambered repeating pistol, revolving by merely pulling the trigger.

There is exhibited in the English collection a revolving gun on this principle by Rigby, of Dublin, which was made 25 years ago, but it was never brought into use; but, what is more remarkable, there is exhibited in the United Service Museum, No. 1180, a revolving gun on this principle which is probably more than 100 years old.

Revolving Hammer (English, 236), has six fixed barrels; the pillars brought up in a circle, and fired by a circular plate, having an elevated block on it, turning on the end of the hammer, so as to fire any barrel upon the pillar of which the block is made to fall.

Safety Locks.—(Exhibitors, 215, 216, 218, 234, 250, 252, 257, 260, 263.)—It is necessary to allude to the numbers as we proceed. (260.) This has a spring behind the trigger-guard, which being compressed by the hand when the gun is put to the shoulder, frees the lock and allows it to be fired. 257 has a hood for covering the percussion cap, so as to protect it from the weather or a blow, and which is

raised when the gun is placed to the shoulder by pressing in a spring. In 215 is a different arrangement in the butt for effecting the same object; while, in 256, there is a bolt before the hammer, which is withdrawn when the gun is pressed against the shoulder. (252.) In this lock there is a "dog" acting on the back of the hammer, which is freed by the pressure of the thumb when the hand holds the gun to the shoulder; and in 218 there is a spring behind the trigger-guard, which must be pressed before the gun can be fired. (216.) In this the spring behind the trigger-guard, when pressed, withdraws a bolt in the trigger, which allows it then to be pulled; the others also exhibit some slight peculiarities.

Belgian. (503.)—This lock cannot be fired unless the gun is both pressed against the shoulder and grasped behind the trigger-guard. This safety-lock can be used or not, as may be desired.

Falise & Trassmann exhibit a specimen of the regulation Spanish musket, with a guard for the cap, securing it from the weather and from accident, which might be advantageously adopted in all services. A similar arrangement will be found in the French (509).

Jersey. (19.)—This superb article has no less than three stops to the lock; one is a bolt, which cannot be withdrawn without first pressing on a screw on the plate of the lock, and the gun cannot be cocked unless the trigger is pulled at the same time.

Self-priming Locks. (Exhibitors, English, 218, 232, 257, 260, 265; Belgium, 140; Portugal, 638.)—The first is a rotary priming musket. The caps are placed in a circular frame at the side of the lock, which is turned round so as to bring them in succession under the hammer, which is also at the side. In the second, the caps are placed in a groove in the stock, and brought on the pillar in succession by the mere act of cocking the gun. In the third, the caps are placed in narrow chambers on each side of the elevated rib between the barrels, and are adjusted on

the pillars by the mere act of cocking; and the other is a self-priming military musket and double gun, with reservoir of caps in the stock and in the butt, placed on the pillars by the act of cocking.

In the Portuguese collection will be found detonating locks effected by turning round a magazine similar to those at 257 in the English collection.

In the example which has been furnished from Belgium (140), the caps are placed on the pillars by the action of cocking the gun.

Lock of simple Construction. (Belgium, Le Dent, 148; France, 618; England, 323.) — A lock has recently been patented of extreme simplicity of construction; it, in fact, consists of only three parts, viz., the hammer, the plate, and one spring, and these are put together with three screws only. The spring is V-shaped, and acts like a double spring. Two pegs, in the round part of the hammer, above and below the pivot on which it turns, pass through holes in the plate, the one above and the other below the V-spring; in pulling back the cock the upper part of the spring is forced down, whilst the lower peg is moved along the lower arm of the spring, in which there are notches which hold the hammer at full or half cock.

France. (618.)—Is nearly the same as the above, but only that the notches for holding it cocked are in the upper, instead of the lower part of the V-spring; this is put together with two screws only instead of three.

Locks of peculiar Construction.—These will be found deserving of notice rather from peculiarities and ingenious contrivances than practical utility. They will be discovered as follows:—

France. (468.)—Pistols with locks under the barrels.

English. (200.)—Nearly the same arrangement; (297) is an invisible lock in the stock.

Prussia. (678).—Not very different.

English. (59.)—A rifle with a lock which acts either as a needle-gun or as an ordinary percussion gun.

Swiss. (265.)—A double-barrelled rifle, with only one trigger. (67.) A single rifle, with two locks, but only one trigger. This rifle is loaded with two charges at the same time, which can be fired one after the other.

Portugal. (639.)—A flint-lock made in 1778, the lock is immediately behind the breech in the stock, and covered over with a curved plate, so as to entirely hide it in the stock; when the trigger is pulled, the plate is thrown over at the same moment that the lock acts.

(640.)—A lock, arranged for firing either as a detonator or as a flint lock; there is a cylinder containing on one part a pan for holding the powder, and on another, a pillar for the copper caps, and the cock is arranged so as either to knock up the hammer or to fall on the copper cap—the cylinder can be turned so as to admit of either being used.

Harpoon Gun. (59.)—The *harpoons* used for killing whales can only be thrown by the hand about ten yards, hence the whaler is often disappointed by not being able to reach the fish from a greater distance. By discharging them from a gun, they can be thrown fifty yards with great accuracy.

Duck Guns. (Exhibitors 59, 200, 205, 234.)—*Duck guns* for shooting from a punt at all kinds of wild-fowl are usually about 8 feet long and 1½ inches bore, and throw 1½ lb. of shot; they are mounted on a swivel to fix in a stanchion in the bow of the boat.

We have exhibited a duck gun, with Colonel Hawker's improved ignition tubes; and Colonel Hawker's own duck gun; another with central fire, having trunnions and buffer-springs; and a stanchion duck gun.

France (473) exhibits a gun for throwing a cylinder containing a line coiled in it, to ships in distress, to enable them to effect a communication with the shore.

Rocket Guns (59) are for the purpose of throwing lines to vessels in distress, by which means stronger ropes may be drawn from the ship to the shore, and a communication made by which the people on board may be saved. There are many plans for effecting this by mortar rockets, &c.

Captain Manby, the original inventor, exhibits one. By discharging the rocket from a gun the firing of the rocket is made to sustain the velocity it at first received: these will carry a line from 6 to 700 yards.

Flint Locks. (Exhibitors, English 235, 256.)—Flint locks have been gradually going out of use for the last thirty years, the greater certainty and quickness of the percussion lock giving it advantage over the flint lock, as marked as those of the flint over the match lock described by Lord Orrery. When first introduced a wheel was made to revolve against the flint, but these soon gave place to the lock in the form in which we see it. There are many specimens of flint guns as made for the foreign markets, and one showing the manner in which flint guns were turned into percussion. In Turkey there are several guns and pistols, the locks of which are highly ornamented. In the Russian department will be found a Caucasian rifle, the lock inlaid with gold, and in India, several with Damascus twist barrels; while Tunis furnishes a number of flint locks of very curious construction inlaid with silver.

Matchlocks.—The matchlock in this country gradually gave place to the flint lock, as the latter has given way to the detonating locks; but the matchlock is still in use in many countries, particularly in India, China, and Turkey. The match, which was made of a piece of loose rope dipped in nitre, was held in a notch in what we should call the hammer, which when the trigger was pulled was pressed down into the pan. The powder used as priming was mealed, that it might more readily take fire: it was part of the drill to "blow your match" by word of command; but as the moment of explosion was very uncertain, the fire from these kind of guns is very ineffective.

In the *Indian* collection there are several matchlocks superbly ornamented, and inlaid with gold and silver; the barrels of some of which have beautiful "twists." In the Turkish collection there are also some handsome specimens.

The Earl of Orrery, in 1677, says, "If you fire not the match-lock musquet as soon as you have blown the match (which often in hedge fight and sieges you cannot do), you must a second time blow your match, or the ashes it gathers hinder it from firing. The match being carried loose is very dangerous when the bandeliers run to the budge-barrel to refill their bandeliers. I have often seen sad instances thereof. The light of the match discovered the men at night in sieges. In wet weather the pan having to be kept open some time, the rain deadens the powder and the match too; whilst in high winds the soldier fires his musquet before he intends, and so he loses his shot, and perhaps kills or wounds some one before him. Whereas in the firelock the motion is so sudden, that what makes the cock fall on the hammer, strikes fire and opens the pan at once."

Air-guns. (Exhibitors, English, 222, 224, 237, 243, 247, 254, 259; Belgium, 143, 254, &c.)—In these guns, air is forcibly compressed into a reservoir by an air-pump, worked either by the direct action of the hand, or by winches, or, as has lately been invented, by the elasticity of vulcanized India-rubber. They are chiefly used for firing at a target, or for shooting rooks or rabbits, and they have an effective range of about forty yards.

There are a great number of these in the Exhibition, designed as guns or walking canes, &c. The Prussians (79) exhibit an air-gun and pistol, worked by a winch, and for projecting bolts. Many of the above are very beautifully executed. In (254,) a piece of India-rubber secured under the muzzle of the gun, and connected with the piston of the air-pump, in the lower half of the barrel, is drawn down by the hand, and when released by the trigger forcibly compresses the air and projects the ball with great force.

Bows, Cross-bows, and Poisoned Arrows.—The bow is probably the earliest projectile weapon of man. It was long the favourite weapon of the English, and their success in the battles of Cressy and Agincourt has been generally

attributed to their superior skill in its use; they were made of tough ash 6 feet long, with an arrow 3 feet long; and if we can believe what is related of the accuracy with which they could hit a distant object, and the force with which they discharged the arrow, it was only equalled by a first-rate rifle shot of the present day.

A short bolt, called a *quarrel*, was discharged from the cross-bow with great force.

In the *Indian* collection there are several cross-bows, and bows of different kinds, with steel-headed arrows. In the *Ceylon* series there are also specimens used by the natives, and some from British Guiana. In the *English* (269), are specimens of steel-bows and cross-bows, with India-rubber strings, for firing at a mark.

Poisoned arrows, such as are used by the Africans, and in some parts of South America, are exhibited in the *British Guiana* collection: the arrows are about nine inches long, extremely light, with a very fine point dipped in poison. They are carried in a quiver, to which is attached a portion of the jaw of a shark, which is for the purpose of sawing the head of the arrow nearly through, that it may break off in the wound: this is done by merely turning it between two of the serrated edges of the teeth. A small quantity of cotton is attached to the end of the arrow, which is then blown through a long tube, and will reach an object at a considerable distance with great truth. The arrows are dipped in the poison called "wourali," which is extracted from indigenous plants, and prepared with much care and sundry incantations; its effect is most deadly, quickly killing a man or the largest animal.

Swords, Daggers, and Spears.—(Exhibitors, England, 200, 211, 244, 248; France, 1364, 1582; Wirtemberg, 14; Spain, Russia, Prussia, Turkey, Tunis, &c.)

Although we know that Tubal-Cain (the Vulcan of the heathen mythology, according to some) was "an instructor of every artificer in brass and iron," some 5,500 years ago, it does not appear that the art of tempering iron was

known till a much later time. The most ancient swords we know of were made of bronze, composed of nine parts of copper to one of tin; and what is very remarkable, the composition of the metal in those from Egypt, or Scandinavia, or Ireland, is identically the same.

The best steel was probably first produced in India, in the Punjaub, from whence there are so many beautiful specimens of swords and daggers and other articles, proving that they are still capable of producing the finest tempered swords in the world. Norica, amongst the Romans, was as celebrated for the superior quality of the swords made, from the ore of that country, as Damascus and Toledo have been in their turn for their swords.

The finest tempered and most beautifully watered swords are made from the "wootz"-steel of India, which contains 1·6 per cent. of carbon. This watered appearance is produced, as in the gun-barrels, by mixing and welding together pieces of steel containing different proportions of carbon, and then hammering and tempering the compound bar.

In the *Indian* collection there are a great many very beautiful swords, daggers, spears, and battle-axes. They are remarkable no less for the quality of the steel, than for the elegance of their design and workmanship.

No. 244 is an *English* collection of fine steel, and the sword-blade, in its different stages of manufacture, from the bar to the highly-finished weapon.

Amongst the *Spanish* arms we find the Toledo blades, and curious circular scabbards, in which the blades remain curved, but regain their straightness when drawn.

Egypt contributes the Curra, Khorassan, or black Persian steel, and Russia, the Sashka-shaska of the Caucasians.

Prussia and Turkey contribute many examples of swords and daggers; but they have no great peculiarity in metal or make.

The gold sword presented to Lord Beresford by the officers who served under him in the Peninsular war, is exhi-

bited in the section of Portugal. The hilt is of pure gold, inlaid with diamonds; the sheath is entirely of gold, with bas-relief representations of the principal personal incidents of the actions in which his Lordship was engaged.

In *Tunis* are some of an inferior description, one of which is bent the reverse of the usual way; and in the *Chinese* collection are three swords of inferior workmanship; but there is rather a curious one made of the coins of mixed metals of the country (copper and lead), which we may fancy is for the punishment of usurers.

There are several light spears in the Indian collection; and examples of the lance heads of the Cossacks in the Russian.

An assagai, or light spear, used by the natives at the Cape, with whom we are now at war, is exhibited with the Guiana collection.

Coats of Mail, Breastplates and Helmets, and Shields.— In the *Indian* collection there are several shirts or coats of mail, with the rings gilded to form patterns. There are two from Lahore, which, with the helmets, much remind us of the drawings of the Assyrian warriors on the marbles from Nineveh. One of these suits has plates of steel in it overlapping each other as in the breastplates of the Romans. As forming part of the armour, the steel gauntlets with swords attached to them are worthy of notice, both on account of their singularity, and on account of the superb manner in which they are inlaid.

In the *English* collection (200), is a chain shirt of mail made of steel, electro-plated with silver. This, with the helmet to correspond, is for the Indian cavalry, and (212) a cuirass of steel beautifully ornamented.

In the *Prussian* (667), there are specimens of wrought-steel cuirasses which have been fired at, at 10 yards distance only, and have resisted the force of a musket-ball.

In the *Russian*, there is a brass cuirass.

In the *Indian*, there are several very handsome small round shields very elegantly inlaid with gold, one of which

has four gold bosses in the centre, in each of which there is a pistol, which can be fired from behind, and, as it were, under cover.

In the *French* collection (1364), there are shields of elegant design in bas-relief; but these, like the one near the great diamond, and those amongst the collection in the precious metals, are for ornament only.

Stone Hatchets.—It is a very remarkable circumstance that wherever the arms of the early inhabitants of any country have been found, as they frequently are, in their burial-places, the tumuli of England, or Ireland, or in France or Greece, or in the West India islands, and other places, that not only does the shape of the stone hatchets found resemble those of the New Zealander of the present day, but the stone selected is also in many cases so alike, that it is difficult to distinguish the one taken from the tomb where it has rested not less than 2,000 years on one side of the globe, with that now used by savage islanders at the antipodes. They are usually made of black chert or hornstone; the rarer and more valuable are made of jade. The collection from New Zealand (30) does not contain good specimens of stone-hatchets, though there is a very good specimen of jade unwrought into form. These stones are fixed in a cleft or hole in the end of a wooden handle, and firmly secured there by thongs of hide.

The engineering portion of this Class is embraced in the general review of the machinery and engineering of the Exhibition.

Class XXI.—Cutlery—Edge and Hand Tools.

Situation of Class.—*In the North Gallery between the Pillars* F. 23 *to* 25.

This is a very small class, which has been placed by itself in the Gallery, for the purpose of including those articles which could not be embraced in the Section devoted to General Hardware. There are but 46 exhibitors in this Class; and since it is not intended to express in this Handbook any opinion on manufactures, but little more can be done than to indicate the several kinds of articles exhibited. These are of a very similar character, consisting of (12) razors, penknives, scissors, dessert knives and forks, table knives, and razors in different stages of manufacture; (2) scissors with ornamental handles, chatelaines, model axes, razors, knives, &c.; (18) circular saws, tools, &c.; (7) and (10) town-made table cutlery; (24) lathes and tools; (13) tools, razors, knives, scissors, needles, &c.

The peculiarities of steel manufacture have been sufficiently indicated in the notices of Sheffield manufactures (p. 97), to which the reader is referred. Amongst the razors will be observed some arrangements by which, under any ordinary circumstances, the instruments are prevented from cutting (21). The Plantagenet guard razors and the registered razor guard are somewhat similar in principle: in either case the object being to insure the same angle, under all conditions, for the instrument as it passes over the face. In these cases will be seen the process of manufacture from the raw iron of Dannemora to the finished blade; and these specimens may be advantageously inspected.

That the peculiarities of this class may be seen, we select a few other examples worthy of attention:—

(26.) *Cutlery.* Razor blades from the bar of steel to the

finished blade, and a pair of razors the same as made for Prince Albert. (36.) A brace with all kinds of bitts used for boring, drilling, &c. (39.) Blister and shear steel, cast steel, Lancashire files and tools. *Magnets* made according to the plan of the Rev. W. Scoresby. The object aimed at, in the processes suggested by the experiments of Dr. Scoresby, is to give the greatest possible amount of attractive force to masses of steel: this is effected by the peculiar method of magnetising, which is performed by placing two bar-magnets of the highest power in a straight line with their opposite poles near each other. Upon these the bar to be magnetised is laid, and the magnets drawn asunder in opposite directions, until the bar rests with its two extremities upon the ends of the magnets. It is allowed to remain for a short time in this position, then slid off sideways, turned over, and again treated in the same manner. (4.) Improved table cutlery, emigrants and travellers' protectors (very large knives). (46.) Cutlery, cut-steel chatelaine; door and window wedge—the utility of this design arises from its form: any door to which it is applied is securely fastened, and on an attempt to force an entrance a loud alarm is given by the explosion of an electric ball placed within the wedge, and the door still remains secure from entrance.

Razor Strops. (Exhibitors 5, 9, 21, 34.)—The various parties exhibiting these very useful articles, respectively point out the merits of each kind, and claim certain peculiarities in their construction. To these statements we must refer the curious.

Essentially razor strops are formed of two kinds of leather; one side being covered with one of the fine abrading oxides of iron, and the other with a mixture of plumbago with some moderately tenacious substance.

Walby's Patent Hinges are worthy of notice. The patent rising and spring hinge is constructed on the principle of two inclined planes; the weight is borne equally by each incline, which prevents the pin being strained, and the hinge getting out of order.

Amongst the other varieties must be named—

A masticating knife and fork, 28; the object of which is to cut the meat so thoroughly, that the stomach may be relieved from some of its ordinary labour.

A knife with 300 blades, 40; each has a separate spring, which is certainly ingenious.

No. 25 is another example of a penknife, with a great many blades.

And in 33 we have, as an example of cutlery, a very large razor.

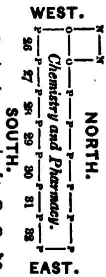
Augurs, 31, from very large to small size; shipwrights' tools, &c.; ladies and gentlemen's skates, needles, and a few surgical instruments, constitute the remainder of this group.

Beyond this brief notice—since it is impossible to determine by inspection the quality of the steel employed in the manufacture of these articles—it is not necessary to offer any explanatory remarks. A considerable advance has been made in this country in the manufacture of steel fitted for cutting instruments; but the peculiar characteristics of the Swedish and Russian iron are such as to insure a continuance of its use for the finer kinds of cutlery.

Class II.—Chemical and Pharmaceutical Products.

Division 1.

Situation of Class.—*In the South Gallery, between the Pillars O. and P., from 25 to 32 chiefly.*



Position of Groups.—(Numbers referring to Pillars.) Chemical Preparations, 26-28. Pharmaceutical Preparations, Pigments, &c., 28-30. These are, however, considerably interspersed.

Sulphate of Copper. (Exhibitors 1, 7, 10.)—This compound of sulphuric acid and copper may be obtained directly by dissolving oxide of copper in that acid, and evaporating the solution. It is sometimes obtained by roasting the poor ores of copper containing sulphur. The sulphur combining with oxygen forms sulphuric acid, which unites with the copper and produces the sulphate; this is washed out of the heaps, and the solution allowed to crystallize. Blue vitriol, as this salt is commonly called, is sometimes found native; but this usually arises from the spontaneous decomposition of a lode of copper pyrites; the sulphate of copper being washed out of it by water filtering through it, which afterwards crystallizes on some neighbouring rocks. In many mines, particularly near the large copper deposits of the Isle of Anglesey and in Wicklow, the water flowing from the mine holds a sufficient quantity of this salt in solution to render it of importance to collect. The usual process of obtaining it is, however, to oxidise sheets of old copper by roasting in a reverberatory furnace, and then heating the oxide in leaden vessels with some diluted sulpuric acid.

In some cases sulphate of copper is produced by the direct combination of copper, sulphur, and oxygen. The metal employed for this purpose is the coppering of

vessels which has become so much worn as to require removal. These sheets are heated to dull redness in a properly constructed reverberatory furnace, and sulphur is thrown in, all the openings of the apparatus being carefully closed up. By this means the metal is rapidly acted on by the sulphur, and disulphuret of copper is formed.

These sheets are afterwards roasted in the same furnace, with free access of air, which converts the sulphur into sulphuric acid, and a subsulphate of oxide of copper is formed. At this point of the operation the subsalt is withdrawn from the apparatus; and, after being allowed to cool, is heated, with a proper quantity of dilute sulphuric acid, in large leaden vessels, where it is converted into the neutral sulphate of protoxide of copper. The liquid from these leaden cisterns is concentrated and crystallized in the usual way, and the mother liquors which remain in the tub after the first crystallization are again evaporated, and a new batch of crystals obtained. After being separately treated in this way, the mother waters become too strongly acid to yield good crystals, and they are then employed, in the place of sulphuric acid, to effect the solution of the subsalt of copper. Sulphate of copper is largely employed in the production of many pigments, as emerald-green,—and in the electrotype processes. Its medicinal use is exceedingly limited, whether as an external application or as an internal remedy. In large doses it is an emetic, and acts energetically as a poison; in very small doses it is powerfully tonic, and has been used with advantage in pulmonary diseases. Farmers employ it for preventing the rot in sheep; and, by steeping grain in a solution of it, for protecting the wheat and barley from the attack of several injurious fungii.

Rochelle Salts. (1.)—This—the *Soda tartarizata* of the "Pharmacopœia," called in old works *Sel de Seignette*, is a tartrate of potash and soda. It was first prepared at Rochelle by an apothecary of the name of Seignette. It is formed by saturating the excess of acid in tartar with car-

bonate of soda. By analysis it is found to contain potash, 15·9; soda, 10·6; tartaric acid, 43·7; water of crystallization, 29·8, or, according to Vauquelin, tartrate of potash, 54; tartrate of soda, 46.

Tartaric Acid. (Exhibitors 1, 11, 86.)—This acid is manufactured from argols or tartar, which is the crude bitartrate of potash deposited by wines in their fermenting vats, in proportion as the alchohol is formed, in consequence of its insolubility in that liquid. There are two kinds of tartars known in commerce—the white and red—usually sold as the white and red argol: the former, which is of a pale pinkish colour, is the crust which falls during the fermentation of white wines; the second is a dark-red substance, and is deposited by the red wines under similar circumstances. This salt, after being purified by repeated boilings with white argillaceous clay, becomes perfectly white, and is then known in commerce under the name of cream of tartar, in which form it is much employed by dyers and calico printers.

The manufacture of tartaric acid is carried on largely in the neighbourhood of the metropolis, and is conducted in the following way:—Into a tub, capable of containing three or four thousand gallons of water, from 16 to 18 cwt. of finely washed chalk (carbonate of lime) is thrown, which is agitated by means of a moveable arm worked by machinery, until it has become incorporated with the water, and forms a sort of milky fluid. The mixture is now heated to the boiling point by the aid of steam, which is introduced into it through proper pipes, and the tartar is afterwards added to it by degrees, and well stirred by the instrument before described. By this means the tartar is made to yield to the lime exactly one-half of its tartaric acid, tartrate of lime being deposited with evolution of carbonic acid gas, whilst neutral tartrate of potash remains in solution. To decompose this second atom, and separate from its base the portion of tartaric acid still united to potash, a proper amount of sulphate of

lime is added to the mixture, which, on being again heated and stirred, is found to consist of insoluble tartrate of lime, deposited at the bottom of the tun, together with a solution of sulphate of potash, which is drawn off, and evaporated in proper vessels, in order to obtain that salt in a crystallized and marketable form.

The tartrate of lime remaining at the bottom of the tun is well washed with pure water, and decomposed by the addition of dilute sulphuric acid, into free tartaric acid (which is dissolved by the water) and insoluble sulphate of lime or gypsum, which settles at the bottom of the vessel. To separate the solution of tartaric acid from the insoluble gypsum with which it is associated, a system of filtration on a large scale is had recourse to; the clear liquor which passes through, being pumped into large evaporators, whilst the solid sulphate of lime is reserved to produce the decomposition of neutral tartrate of potash in the succeeding operation. The vessels in which the weak tartaric acid liquors are evaporated down are commonly made of wood, lined with sheet lead, and the heat is obtained by passing through the liquid coils of leaden pipes, through which a current of steam, at a considerable pressure, is made to pass.

The liquors, after being concentrated to the proper point, are now run off into large leaden tubs, where crystals of crude or rough acid are quickly formed. These are subsequently redissolved, the solution is filtered through a layer of animal charcoal, for the purpose of removing the brown tint caused by the extractive matter contained in the argols. By successive crystallizations and filtrations the acid is in this way made to assume a great degree of transparency, and when crystallized from solutions which are not too highly saturated, the finest specimens are obtained. The tartaric acid of commerce is apt to be contaminated by the traces of sulphuric acid and of lead; the latter being derived from the vessels used in its manufacture.

Citric Acid. (Exhibitors 1, 11, 86.)—The pleasant acid of a great number of fruits is due to the presence of this compound. Citric acid is manufactured from the concentrated juice of the lemon and lime. The methods by which this acid is obtained from the imported lime-juice very closely resemble those employed in the manufacture of tartaric acid. It is, however, far more expensive than tartaric acid, and is, consequently, sometimes adulterated with the latter. This adulteration is easily discovered by the addition of a little carbonate of potash to the suspected acid; for if tartaric acid be present, a precipitate of cream of tartar will quickly take place, whilst if pure citric acid be thus treated, no sort of deposit will be produced. Among the salts of this acid which are exhibited, we may notice a specimen of effervescent citrate of magnesia, which is merely a mixture of the citric acid with carbonate of magnesia in a dry state.

The preparation of this acid is carried on by a few manufacturers on an extensive scale, and it is sent into the market in different states of purity. The average proportion of citric acid afforded by a gallon of good lemon-juice is about 8 ounces, but by great care 12 ounces has sometimes been obtained. M. Tilloy, of Dijon, recommends currants as a source of citric acid: they are bruised, and the expressed juice is fermented and then distilled to obtain the alcohol; the residue is saturated by chalk, and the washed citrate of lime decomposed by sulphuric acid.

Acetate, and other Salts of Lead. (Exhibitors 2, 86.)—Acetate of lead, commonly called sugar of lead, is prepared by dissolving litharge, by the aid of heat, in strong vinegar until the acid is saturated, and by subsequently concentrating and crystallizing the solution. The combination of the acid and litharge may be made either in a copper boiler rendered negatively electrical by soldering a strap of lead along its bottom, or, what is still better, in vessels made of thick sheet lead; in which case it is necessary to keep the liquor constantly slightly acid, in order to prevent

the formation of any of the numerous subsalts which would otherwise be produced.

Salt-glazed stoneware vessels are those best adapted for the crystallization of sugar of lead, and the edges of these should be smeared over with grease or tallow, to prevent the salt from creeping over them by efflorescent vegetation, which it is extremely disposed to do, often assuming very beautiful forms.

When the solution ceases to yield good crystals by evaporation, it is decomposed by carbonate of soda, or lime, carefully applied, by which a carbonate, or oxide, is obtained, fit to be treated with a fresh quantity of acid or vinegar. Acetate of lead is a poisonous salt, having no smell, but a sweetish taste, not unlike that of sugar, and from hence its common name, sugar of lead. It is much used for calico printing as a mordant base.

Nitrate of Lead is obtained by dissolving litharge, not in excess, in hot nitric acid diluted with two parts of water. This salt is also employed by the calico printer, and it is used in dyeing.

Oxichloride of Lead. (12.)—There is another case in this collection which is deserving of notice. It contains a series of specimens to illustrate the manufacture of a new white pigment of lead, viz., the neutral oxichloride (Pl Cl Pl O, or an atom of chloride of lead united to an atom of oxide of lead), recently discovered (with the process of obtaining it) by Mr. H. L. Pattinson, of Scots' House, near Newcastle-upon-Tyne. This substance is made by dissolving galena or sulphuret of lead in muriatic acid, the latter having now become a large waste product in this country, and therefore costing nothing. By this operation the sulphur of the galena is expelled in the form of sulphuretted hydrogen gas, which may be burnt to form sulphuric acid, and the metals, silver and lead, contained in the ore, are converted into chloride of silver and chloride of lead. The mixed chlorides are placed in hot water, when the chloride of lead dissolves, and the insoluble chloride of silver, which

settles to the bottom of this solution, is collected and afterwards reduced into metallic silver by an easy process. To the solution of chloride of lead, lime-water is added in the proportion of half an equivalent of lime to one atom of chloride of lead, when the whole of the lead is precipitated as neutral oxichloride of lead, forming, when collected and dried, the pigment under description. This new pigment possesses great body, and is of a brilliant white colour. It is already made to some extent, and is likely to become an important branch of chemical manufacture.

The case contains—

1. Rough galena.
2. Finely ground galena.
3. Muriatic acid.
4. Chloride of lead.
5. Oxichloride pulp, as precipitated by lime.
6. Dry oxichloride.
7. Oxichloride, ground with oil.
8. Insoluble residuum containing silver.
9. Small plate of silver made from the residuum.

Upon the adjacent wall are three pictures, painted by Carmichael, about a year ago, entirely with this oxichloride of lead.

Lead and its Salts—White Lead. (59.)—This valuable pigment is a carbonate of lead, united with some oxide of lead. It is prepared by the action of acetic acid upon the metal in the following manner:—

Lead is cast into forms which admit of the largest possible surface being exposed to the action of the vapour of acetic acid. These are usually of the gridiron shape, with the bars crossed. A number of such pieces of lead are placed over an earthenware pot, containing the acid. Some dozens of these pots, thus adjusted, are placed in a stack upon a bed of tan; one layer being completed, it is covered over with boards, and upon these another bed of tan and another set of the vinegar-pots and lead are placed. These are again covered with board and tan; thus the

stack is filled in with layers of tan, vinegar-pots, and lead, the whole being carefully covered in with a thick bed of tan. Fermentation soon takes place in the tan; and by the heat thus generated the acetic acid is vaporized, and it attacks the lead, forming a basic acetate of lead. This is decomposed by the carbonic acid surrounding it, and is converted into basic carbonate of lead, neutral acetate of lead remaining. This, under the action of the air, takes up a new quantity of lead, and the same decomposition is renewed. In this way eventually the lead is corroded throughout, the whole being converted into *white lead*. It is then ground with water under rollers, dried, and eventually either sold as dry white lead, or ground with oil, for the use of painters. The men employed in white lead works suffer from stomach diseases, which arise from the absorption of the carbonate of lead: this, however, is, to a great extent, remedied by taking every precaution, in the way of cleanliness, and in the ventilation of the manufactory, so as to remove as rapidly as possible all dust from the apartment. The men, too, should be encouraged to make use of a drink which is acidified by sulphuric acids, by which the carbonate is converted into a sulphate of lead, which is the most insoluble of the salts of this metal.

Nitrate of Lead is obtained by dissolving lead in dilute nitric acid, and evaporating. It crystallizes in regular octohedrons, as will be seen in many of the crystals exhibited.

Zinc, Sulphate and Oxide—White Zinc. (Exhibitors 7, 57, 61.)—Oxide of zinc, or zinc white, is now becoming extensively employed as a pigment instead of white lead, which was formerly exclusively used for the preparation of white paint. This substance is obtained by exposing melted zinc to a current of air in properly constructed ovens, which are for this purpose usually made of fire-clay, very much in the form of the ordinary coal-gas retort. The zinc, which is an extremely volatile metal, is, by this

treatment driven off in the state of vapour, which, combining with the oxygen of the heated air, forms the white oxide of that metal, the "nihil album" of the ancient alchemists, the *Philosopher's Wool* of moderns. This flocculent product is now conducted into a series of chambers prepared for its condensation, from which it is afterwards taken out in a state fit for being mixed with refined linseed oil, and ground at once into paint. The pigment thus obtained has the advantage over white lead of being unattacked by sulphuretted hydrogen gas, which speedily turns any body covered with ordinary paint to a dark-brown or black colour; and it is consequently well adapted for all purposes in which lead paint would be liable to this inconvenience.

The oxide of zinc, although of a beautifully white colour, is unfortunately, to a certain degree, transparent; and it is stated by painters that it does not possess the covering properties or the body of the carbonate of lead. Another difficulty attending the use of zinc paint arises from the circumstance that it remains on the wood a long time before becoming sufficiently hardened to admit of a second coat being laid on; whilst, as most of the compounds sold under the name of "patent driers" contain lead, the introduction of this substance gives it the property of becoming black when exposed to hydrosulphuric acid, and thus entirely destroys one of its most valuable characteristics. This arises from the fact that the oxide of zinc will not combine with oil to form a plaster in the way in which the oxide of lead does. It is much to be wished that the resources of modern chemistry may be at length found equal to the removal of this disadvantage; as, from the baneful influence exerted by white lead, both on the persons who are employed in its manufacture, and on the painters by whom it is applied, it is greatly to be desired that some good and equally cheap substitute for this substance may be ultimately discovered.

The other salts of zinc exhibited possess no very re-

markable properties. The zinc colours, so called, appear to be only metallic oxides of different kinds mechanically united with the white zinc as a base. From the manner in which the zinc white retains its colour, there can be but little doubt that these will remain permanent for a long period.

Bichromate of Potash and Salts of Chromium. (Exhibitors 8, 41, 59.)—Chromium was discovered by Vauquelin, in some ores of lead from Siberia. Ores containing chromium occur in large quantities near Baltimore in Maryland, the Shetland Isles, in the department of Var in France, near Portsey in Banffshire, and also in Bohemia and Silesia. Of the chromate of lead beautiful specimens are found in Siberia and also in the Brazils. To prepare bichromate of potash (the beautiful yellow crystalline salt exhibited) from this mineral—generally chrome iron or chrome ochre—it is first carefully separated from the gangue with which it is found associated, and it is subsequently ground under heavy edge-runners to the state of a very fine division. It is then mixed with from one-third to one-half its weight of nitrate and carbonate of potash, and exposed to a strong heat, during several successive hours, on the hearth of a reverberating furnace, where it is occasionally stirred about with iron rakes. When the calcination is judged to be sufficiently advanced, the charge of the furnace is withdrawn, while still hot, thrown into vessels containing water, in which the potash salts formed are dissolved. The solution thus obtained is evaporated briskly, and chromate of potash, a lemon-yellow salt, is formed. To the dissolved chromate of potash is added some sulphuric acid, which combines with one-half of the alkali, leaving the other in combination with two atoms of chromic acid, forming the richly-coloured bichromate of potash. This substance is principally employed by colour-makers and dyers, who obtain from it some very beautiful dyes and pigments, by the addition of a soluble salt of lead. A green oxide of chromium is also prepared by the decom-

position of chromate of mercury by heat. This salt is obtained by adding nitrate of protoxide of mercury to chromate of potash in equal proportions; and the oxide which remains when this substance is heated to redness is principally applied to dyeing and painting in porcelain.

The bichromate of potash, heated alone, yields the oxide in dark-green crystals of great beauty. The product is not so beautiful, but is twice as abundant, when sulphur is used. The oxide is employed in painting and glass-staining, as procured by the processes described; it is anhydrous and insoluble in acids. It is obtained hydrated by raising a solution of bichromate of potash, mixed with muriatic acid, to the boiling point, and adding alcohol, in small quantities at a time, till the liquid changes from orange to green. The alcohol deprives the chromic acid of half its oxygen, reducing it to the oxide which forms, with the hydrochloric acid, the sesquichloride of chromium. This acid is obtained almost pure by mixing a cold saturated solution of bichromate of potass with half as much again of oil of vitriol. The sulphuric acid combines with the potass, evolving much heat, and the chromic acid separates in beautiful red crystals as the liquid cools. Chromic acid is exceedingly soluble, and cannot be brought into contact with organic matter, owing to the readiness with which the latter deprives it of half its oxygen. It is employed to bleach palm oil preparatory to its conversion into soap. The salts of the acid are more important than itself. The chromate and bichromate of potass have already been referred to. The chromate of lead, a bright yellow substance, largely used in the arts, is produced by precipitating a solution of acetate of lead by bichromate of potass. If the chromate of lead be boiled with lime-water, or fused with nitre, half the chromic acid is transferred to the alkaline base, and a sub-chromate of the metal, of a beautiful orange red, or vermilion colour, is left.

Soluble Prussian Blue. (3.)—The soluble Prussian blue is prepared by adding nitric acid to the yellow prussiate of potass in solution, to which is immediately added a solution of sulphate of iron. The mass becomes a blue paste, to which a little water may be added when placed on a filter. This is to be washed with water until a solution of iron ceases to strike a blue colour with the percolating water. The precipitate remaining on the filter is a fine Prussian blue, perfectly soluble in rain water. This process has been patented by the Rev. J. B. Reade.

Red and Yellow Prussiates of Potash. (Exhibitors, 13, 27.)—These are the ferro-cyanates of potash of chemists.

Animal substances are employed in the manufacture of these salts, which are compounds of nitrogen and carbon with the alkali.

A large egg-shaped pot of cast iron is built into a furnace, so as to admit of being readily heated to redness. When this vessel has been brought to a moderate state of ignition, a mixture of pearlash and dry animal matters is projected into it; of these hoof, horn, woollen rags, and the substance called greaves, the refuse of tallow-melters, form a principal part. The proportions usually adopted are two parts of pearlash to five parts of animal matter; and this mixture, as it calcines, gradually assumes a thick pasty form: during the progress it is kept constantly stirred about with a long iron bar. A very offensive odour is given off from the retort, while the nitrogenous matters are in process of combination with the alkali; but when the mixture has become wholly converted into a chemical compound, the evolution of the fœtid animal vapours entirely cease; the pasty mass is now quickly withdrawn from the heated vessel by an iron ladle, and allowed to cool before being subjected to any further treatment.

If the charge of the retort were thrown, while still hot, into water, for the purpose of more readily effecting its solution, some of the prussic acid present would be

converted into ammonia, and the usual crystallised product would be diminished in a proportionate degree. When quite cold, the solid matter is dissolved in water, and the solution clarified by subsidence and filtration: the liquor thus obtained is concentrated by evaporation, and, on being allowed to cool, deposits yellow crystals of the ferro-prussiate of potash on the sides of the vessels containing it. When large and pure crystals of the salt are required, the granular deposit is again dissolved in hot water, and it then yields, when allowed to cool slowly, fine and very regular crystals of prussiate of potash.

The salt may be regarded as a compound of cyanide of iron and cyanide of potassium. The iron necessary to the production of this substance is derived from the pot and stirrers used in the operation; and these, therefore, are found to be much corroded and worn away by use. The lower part of the retort, where it comes most in contact with the mass of fused animal matters, is especially subject to be thus acted on, and it is, therefore, frequently necessary to turn it, so that the parts acted on may be placed uppermost, and further removed from the corrosive action of the charges.

This salt is very largely employed for the manufacture of the colour called Prussian blue.

The ferro-prussiate of potash may be also formed by exposing powdered charcoal to an intense white heat for ten hours saturated with 30 per cent. of potash in earthenware cylinders, through which a current of air is made to pass. The atmospheric nitrogen combines with the carbon, and thus cyanogen is produced, which unites with the potash. This is mixed with peroxide of iron and recalcined.

The Red Prussiate of Potash.—If chlorine is passed through a solution of the yellow prussiate, it undergoes a change, and becomes of a greenish colour. From this solution, however, bright red crystals are obtained, which are the ferrid-cyanate of potash, containing potassium

36·14, iron 16·87, carbon 21·68, and nitrogen 25·31, in every hundred parts.

Prussian Blue.—When a salt of iron is added to either of the above salts, a combination is effected of the cyanide compounds and the iron. For the manufacture of the Prussian blue of commerce, the impure liquor obtained by digesting in water the calcined mass of animal matter, from the process above described, is decomposed by an excess of sulphate of iron, the resulting precipitate digested in muriatic acid, and exposed to the air, until it assumes its proper colour.

Gallic Acid. (Exhibitors 106, 107.)—This remarkable substance does not appear to exist naturally formed in plants, except in the seeds of the mango: it is generated by the decomposition of the gallo-tannic acid, which is found in most astringent vegetable substances, as oak-bark, the gall-nut, &c.

Gallic acid may be obtained by mixing powdered galls with water, and exposing the paste for some weeks to the air, at a temperature of about 80° Fahrenheit, and occasionally adding a little water to prevent the mixture from becoming dry. The powder thus treated gradually swells, and becomes mouldy, and on subjecting the pasty mass to pressure, a quantity of dark-coloured liquor is easily squeezed out; the residue, or cake, is now boiled in water, and the solution filtered whilst hot; and on cooling, it deposits long acicular crystals of gallic acid, which may be purified by re-solution and boiling with a little animal charcoal. On again crystallizing this solution, crystals of a much lighter colour are obtained. Gallic acid forms one of the ingredients of common writing ink, the colouring matter of which consists of a mixture of gallate and tannate of iron. It is also the agent employed for the development of the photographic images in the Talbotype process.

Pyro-Gallic Acid, which is employed for the same purpose, may be prepared by carefully heating gallic acid to

about 400°, when it is totally decomposed into carbonic acid and pyro-gallic acid, which sublimes in brilliant white plates.

Oxalic Acid. (11.)—Oxalic acid is chiefly used for discharging colours in certain styles of calico printing: it is also employed for whitening the leather of boot-tops, cleaning straw, and other similar fabrics.

This acid occurs ready formed in the juice of the wood sorrel, where it exists in combination with potash as a binoxalate—a salt which is in Switzerland largely prepared from this source, and sold commonly in this country under the name of salts of sorrel, or salts of lemon. Oxalic acid is much used by the scientific chemist as a means of detecting lime in any solution in which it may exist. For this purpose the oxalate of ammonia, as being more certain and delicate in its action, is more frequently employed than the free acid.

Oxalic acid may be prepared by the action of nitric acid on sugar, silk, saw-dust, hair, glue, and several other animal and vegetable substances; but for commercial purposes sugar and molasses are alone employed, and yield acid of greater purity than that obtained from any of the other above-mentioned commodities. To make this acid, four parts of nitric acid are added in a large stoneware vessel to one part of raw sugar, and the mixture subsequently heated in a water bath until the whole of the nitrous gas which is at first driven off has become totally disengaged. When this point has been attained, the pipkin is removed from the water bath and allowed to cool, by which means the oxalic acid is obtained in a crystallized form.

Morphia and its Salts. (Exhibitors 106, 107.)—Opium, the inspissated juice of the poppy, is prepared in India, Turkey, Persia, and Egypt. It forms a prominent article of commerce between India and China, and yields a large revenue to the Indian government. It is variable in its composition: not only do different countries produce a different opium, but different localities in the same country,

and these vary in their active principles in some cases to an extent of 50 per cent. Morphia is one of the active principles of opium, and on it depends the value of that drug in allaying pain and procuring sleep. It was the first of the organic alkaloids discovered; the precursor of a numerous and energetic family of agents, upon the assistance of which the physician can with confidence rely. Morphia itself from its insolubility is rarely if ever employed. Its salts, however, are now in almost universal use, and they have this advantage over opium, that they are not only uniform in their constitution, but many of the evil consequences which follow a dose of opium, are either much lessened or altogether avoided by their use.

The salts of morphia chiefly employed are the muriate or hydrochlorate, the acetate and sulphate.

To obtain pure morphia, the process invented by Wiltstock is perhaps the best. One part of opium, eight of water, and two of muriatic acid, are to be digested together for six hours; when the mixture has cooled, the brown solution is to be poured off, and the residue treated twice more with water and acid. The liquors so obtained being mixed are to be saturated with common salt, on which they become milky, and after a few hours a brown clotty precipitate forms: this being removed by the filter, ammonia is to be added in slight excess, and the whole allowed to stand for twenty-four hours. The precipitate which forms in this time is to be collected on a filter, washed with a little water, dried, and digested in spirit of specific gravity, 0·820, which dissolves out the morphia. By distillation, the greater part of the spirit is removed, and the morphia being dissolved in a small quantity of boiling alcohol, crystallizes on cooling. In this process the narcotin is separated by the addition of the common salt, in a solution of which it is insoluble; the meconic acid, codein, and thebain, remain dissolved after the addition of the ammonia in excess, and the other principles

present in the opium remain in the mother-liquor after the morphia crystallizes.

The process of Merck is founded on the insolubility of morphia in a solution of sal-ammoniac, and its solubility in lime-water. Opium is to be digested in three times its weight of water, then expressed, and this repeated three or four times: these solutions being mixed, are brought to boil, and milk of lime added in slight excess; the precipitate which forms is to be collected in a strainer and strongly pressed; the liquor is then to be evaporated until it is about twice the weight of the opium employed, and to be then filtered, brought to boil, and for each pound of opium one ounce of sal-ammoniac added in powder. The morphia separates in crystals, and may be purified by boiling with some lime and ivory-black, and precipitation again by sal-ammoniac.

Strichnine, from the Nux-vomica, *Aconita* from the Monkshood, *Aconitum napellus*, *Veratrine* found in the Hellebore, *Veratrum album*, and *Veratrum sabadilla*, and numerous other alkaloids, are exhibited; but it is not possible to describe each process particularly.

Bebeerin (107) is another organic alkaloid, first separated in a pure state by Dr. Douglas Maclagan. It is obtained from the bark or the seeds of the Greenheart tree of British Guiana—the *Nectandra Rodici*, so called from Dr. Rodie, the original discoverer of its medicinal properties. It is employed in the form of sulphate as a general tonic and febrifuge, and has been used instead of sulphate of quinine, the good properties of which in many cases it supplies at a much inferior cost.

It was at one time thought that it was similar to morphia in its elements and their proportions, and the analyses of Maclagan and Tilley gave for it exactly the same formula; but the more recent researches of Dr. A. von Planta show that they are not identical.

Quinine. (Exhibitors 11, 806, 117.)—The bark of the various species of cinchona are well illustrated in 11, and

the collection of the London druggists. These contain three vegetable alkalies, combined with the cinchonic and cinchona-tannic acids. These are quinine, cinchonine, and aricine; of these the quinine is by far the most important, and is generally extracted from the yellow bark. The coarsely-powdered bark is to be boiled with eight to ten parts of water, to which two parts of muriatic acid have been added. When the liquor will dissolve no more it is to be allowed to cool, and to be strained; lime is then to be added in very fine powder until the liquor has a marked alkaline reaction; the precipitate is to be collected on a linen cloth, washed once or twice with water, and then dried: from this boiling alcohol dissolves out quinine and cinchonine; the solution being mixed with water, the alcohol may be distilled off and saved; the residue is then to be neutralized by dilute sulphuric acid, and a slight excess added to form acid salts. On evaporating this liquor to the proper point, the sulphate of quinine crystallizes, whilst the sulphate of cinchonine remains in solution. To obtain pure quinine, solution of sulphate of quinine is to be decomposed by caustic potash, and the white curdy precipitate, being carefully dried, is to be dissolved in the smallest possible quantity of spirits of wine. By then allowing it to evaporate spontaneously in a warm place the pure quinine crystallizes with an atom of combined water.

Camphor. (11.)—The common camphor is obtained from the Camphor laurel (*Laurus camphora*), and the *Dryabalanops camphoræ*, by distillation with water. The large specimen of Borneo or native camphor exhibited is so highly prized by the Chinese that it fetches 78 times the price of common camphor, and therefore rarely comes to this country, this specimen being in fact almost the only one.

Borax. (11.)—The borax series is also worth attention, as it exhibits the boracic acid of Tuscany, from which most of the borax used in England is made; the

tincal or natural borax of Thibet; artificial tincal, showing how that particular form of crystal may be imitated, and some other interesting specimens should be examined.

Alum and Copperas Series. (Exhibitors 4, 6, 7, 16, 17, 18, 40.)—Alum is sometimes discovered in a natural or native state; it occurs in volcanic districts in the form of a white flocculent powder, covering the surface of the lava and other trachytic bodies abounding in such localities. In this form it occurs in Auvergne in the south of France, in Sicily, and the volcanic islands on its northern coasts; but more particularly in the neighbourhood of Naples, in the Grotta di Alume, on Capo Miseno, and in the Solfatara. From these localities it is collected, and dissolved in water, which, after being allowed to deposit the earthy impurities held in suspension, is evaporated, in order to crystallize the alum which it contains. Large quantities are prepared in various localities by the chemical treatment of a mineral known by the name of alum-stone or alum-rock. This is a massive, granular, partially crystallized, transparent, and not homogeneous rock, which frequently encloses quartz—sometimes iron pyrites and manganese ore. This mineral, which is a basic sulphate of alumina united with sulphate of potash, is of a yellowish colour, sometimes passing into green or brown, and is not unfrequently found in the form of distinct crystals. The ordinary alum-rock, although less pure than the crystallized varieties, has an early similar composition, and occurs in considerable quantities, and in a massive state, at Tolfa, near Civita Vecchia, in the Papal States; at Montione, in the dukedom of Piombino; in the Comitats of Beregh and Zemplin, in Hungary; at Mont-d'Or, in France; and in some of the islands of the Greek Archipelago.

Alum was originally made in Syria, and afterwards in the Pope's dominions, from mineral deposits which, when calcined, yielded all the constituents of the alum, sul-

phuric acid, alumina, and potash. A small portion of the article so manufactured is still imported as Roman alum, and although not pure, its peculiar composition makes it suitable for some purposes. When, under the curse of the Vatican, the manufacture of alum was introduced into this country by Sir E. Chaloner, in the reign of Queen Elizabeth, and established at Whitby, in Yorkshire: the alum schist found there would only afford two of the three mineral constituents of alum; sulphuric acid and alumina, ammonia or potash (either being equally suitable) were, therefore, supplied artificially. An immense quantity of the schist is, however, necessary to afford the requisite quantity of alum (130 tons according to Dr. Ure, only yielding one ton). The peculiar constituent of alum being abundant in many minerals it has been often attempted by intelligent manufacturing chemists to bring all the constituents artificially together, and thus produce the article at less expense to meet the immensely increasing consumption. Chaptal, in France, attempted this long ago by exposing balls of burnt clay to sulphurous acid fumes in a vitriol chamber; the sulphate formed, soon by exposure became sulphate of alumina, and was then dissolved out, and converted into alum.

In this country, clays have also been used, but not very successfully; Messrs. Lees and Co., of Newcastle, being almost the only parties who, by great skill in the manufacture, and aided by cheap fuel, have succeeded in maintaining their ground.

In 1845, a patent was obtained by Mr. Spence for the manufacture of alum from the shale of the coal and ironstone measures. This mineral lies in immense heaps around all our coal and ironstone workings, and was perfectly useless: I am not aware of its having ever been attempted to make any use of it before. It is a compound of varying proportions of silica, alumina, oxide of iron, and bituminous matter; it contains no appreciable quantity of sulphur: after calcining it in the open air,

without further preparation, the alumina is extracted by digesting the shale in diluted sulphuric acid, and running off the clear solution of sulphate of alumina of sufficient strength to crystallize alum, after adding ammonia or potash, and no evaporation of the liquor is required; thus avoiding a very expensive part of all the other processes. This manufacture is perfectly successful; four to five thousand tons of alum have been produced annually at the Pendleton Works: three other firms are at work under the patent, and there is little doubt of its ultimately superseding the manufacture of alum by the other modes and materials. This will be apparent, when it is stated, that there is actually produced one ton of alum from one ton of this otherwise useless and superabundant mineral.

Copperas is produced by digesting sulphuric acid on burnt pyrites, which have been used for producing sulphuric acid, in place of sulphur. Any of the bisulphurets of iron suit the purpose, provided they contain no other metals. The pyrites collected around the Isle of Sheppy, and along the south-east coast of England, and extensively used in London for making sulphuric acid, are exceedingly suitable; also the pyrites of the coal measures. One of the crystals of copperas shown is made by Messrs. G. Brown and Co., of Bow Common, who use both Sheppy and coal pyrites in their vitriol manufacture.

Practically, by the patent process, the pyrites yield copperas of first-rate quality (being a pure protosulphate of iron), equal in quantity to the original weight of the pyrites, and requires for this, less than one-half of the sulphuric acid which has been obtained from it by burning; no evaporation is required, and the cost of the copperas is not above two-thirds of its cost by the old mode of manufacture.

Hydraulic Mortar. (11.)—Refuse shale from the alum process, and refuse lime from gas purifying (which is of little use), are claimed by the patentee as constituents of

this cement, and also the introduction of zinc oxide, which is obtained as sulphate of zinc from the burnt Wicklow pyrites. In the calcination of the materials, it is reduced to oxide, and by its affinity for oxygen, prevents the oxidation of any iron present, and thus maintains a light stone colour: it also prevents the growth of moss, &c. This cement is hydraulic, hardening under water.

Salt. (Exhibitors 30, 116; Class I., 57, 58; and, in Class III., 118.)—Cheshire produces a large quantity of salt, of which some fine masses of rock salt are exhibited.

At Droitwich, Worcestershire, the salt manufacture has been in operation from a very early period. It is mentioned by old writers at the time of the Roman invasion; but was carried on in a very primitive form, and at considerable expense.

The brine springs here extend over a very limited space of land, and are comprised within a circle of about 200 yards diameter. The brine was formerly obtained by boring, which then rose to the surface, and ran away to waste; but coming through and mixing with the fresh-water springs, it was lowered in strength. Consequently, the manufacture of salt (which is obtained by evaporation) was attended with great expense, from the quantity of fuel required to vaporize the water. Within the last fifty years an improvement was effected by casing the pit with wood, and thus partially preventing the fresh water mixing with the brine. More recently, the principle was introduced of sinking quite through the fresh-water springs, and then making the bottom and sides of the pit secure with iron cylinders before boring down to the brine springs. By this means the brine is obtained at full saturation, or about 42 parts of salt in the 100, whereas formerly it averaged from 28 to 37.

The body of brine in Droitwich is inexhaustible, and exhibits no diminution in strength or quality. It lies at a depth of 173 feet from the surface; but as soon as it is reached by boring, it rises to the surface.

The salt manufactured is exported largely from the ports of London, Gloucester, and Bristol. There is now upwards of 70,000 tons per annum made in Droitwich; 40,000 tons of which are used for domestic or agricultural purposes, the remainder chiefly for chemical manufacture and exportation.

Orchil—Cudbear. (68. See also Vegetable Dyes, p. 163.) —Orchil and cudbear are various forms of colouring matter prepared from lichens by the action of ammonia.

It is a mistake to suppose, as is usual, that the distinction of blue and red in those articles is occasioned merely by excess of alkali in one case, and deficiency in the other. The difference is brought about by modes of preparation diverse in character, and the two forms of colouring matter are quite distinct in chemical composition. The blue form of orchil is allied to litmus in its nature and properties. Cudbear is a dry form of these matters reduced to powder.

These colours do not succeed well as pigments, being rather heavy and dull when dry, though extremely beautiful when moist. There are a few specimens illustrative of such application in the bouquet of flowers in wax exhibited; carbonate of barytes being employed to preserve the peculiar hue of the colours.

The colours of the feather flowers are more successful, feathers, like most animal matters, taking the dye pretty easily. Marble is easily stained by orchil, particularly by the blue kind, and the effect is very beautiful. It is merely necessary to apply the solution to the surface (not polished), and in a few hours it will penetrate frequently to the depth of an inch.

We believe that the application to wood-staining might be carried out to greater extent than at present. The specimens exhibited show some of the varieties of tint which may be obtained in this way. When blue orchil is employed alone, and then varnished, the result is a colour approaching to that of rosewood, as the varnish

acts upon the colouring matter, and alters its hue. By washing the surface of the wood over with a solution of soda, after staining it with the blue orchil, and defending it by a coating of the ammoniacal shell-lac varnish, we have succeeded very well in preserving the purple tint.

It was generally supposed by the manufacturer, till within the last 10 or 12 years, that all lichens applicable to the production of orchil grew upon the bare surfaces of rocks. This is now proved to be an error, for the orchilla weed from Angola, which is peculiarly rich in colouring-matter, grows parasitically upon a species of thorn. Within the last few months a description has been imported from Angola which does grow upon rocks; but this is quite different in structure to that first mentioned as growing upon trees. Dr. Lindley considers this first mentioned to be a "*ramalina*, not apparently different from *Ramalina farinacea*," and recommends the trial of British ramalinas to ascertain if some of them do not likewise contain the same or analogous colouring principles.

The following is a list of the principal varieties of the Lichens exhibited:—

Angola Orchilla Weed (*Rocella montagnei*), from Angola, coast of Africa.

Thick Lima Weed (*Rocella tinctoria*), from Lima, South America.

Lima Weed (*Rocella fuciformis*).

Canary Orchilla Weed (*Rocella tinctoria*), from Canary Islands.

Canary Rock Moss (*Peremela perlata*), from Canary Islands.

Pustulatus Moss (*Gyrophora pustulata*), from Norway.

Cape de Verd Moss (*Rocella tinctoria*), from Cape de Verd Islands.

The peculiarities of these colouring matters have been fully investigated by Professor Stenhouse and Dr. Schunck.

Class II.—Chemical and Pharmaceutical Products.

Division 2.

Iodine. (Exhibitors 11, 32, 37, 86, 89.)—This substance was discovered by Courtois, a soap-boiler of Paris, in the vessels containing the soap ley, obtained from a solution of the alkali contained in the ashes of sea-weed.

This substance may be procured by drying and powdering common sea-weed, and heating it with sulphuric acid. A violet-coloured vapour rises, which, if received in a cool vessel, will condense on its sides, and will form scaly crystals of a somewhat metallic lustre. These crystals are the substance in question. From the violet colour of its vapour it is called iodine. When exposed to the air at common temperatures, it volatilises slowly but completely, but in close vessels it requires the application of heat for evaporation. At a heat a little above that of boiling water it melts; at 350° it boils and evaporates in a violet-coloured vapour, almost exactly the colour of the vapour discharged from indigo thrown on hot iron. It crystallizes as it cools. Iodine is largely contained in kelp (the semi-fused ashes of sea-weed), and it may be economically prepared from the brown oily-looking liquor which is the waste of the soap manufacture, and in which all the iodine originally contained in the kelp used in that manufacture is to be found.

Every eight ounces, apothecaries' measure, are to be mixed hot with one ounce measure of sulphuric acid, diluted with its bulk of water. When cold, filter the liquor, add 666 grains of black oxide of manganese, and introduce the whole into a large glass globe, over the wide neck of which another is to be inverted and kept cool, while the bottom of the lower one is heated by burning charcoal to

about 232°. Iodine now sublimes copiously, and is readily condensed in the upper vessel. From the above quantities about one drachm troy will be obtained.

Bromine. (Exhibitors 37, 50.)—This peculiarly interesting substance was discovered by M. Balard, of Montpelier, and the first description of its properties appeared in the "Annales de Chimie et de Physique" for August, 1826. The name originally applied to it was muriate, but it has been since changed to brome, a word derived from the Greek, signifying a strong or rank odour. This appellation may be conveniently changed in English to that of bromine. Bromine in its chemical relations bears a close analogy to chlorine and iodine, and has hitherto been always found in nature associated with the former, and sometimes also with the latter. It exists in sea-water in the form of hydrobrome, and combined, in the opinion of M. Balard, with magnesia. Its relative quantity, however, is very minute; and even the uncrystallizable residue called bittern, left after the muriate of soda has been separated from sea-water by crystallization, contains it in small proportion. It may apparently be regarded as an essential ingredient of the saline matter of the ocean, for it has been detected in the waters of the Mediterranean, Baltic, North Sea, and Frith of Forth. It has also been found in the waters of the Dead Sea, and in a variety of salt springs in Germany. M. Balard found that it exists in marine plants growing on the shores of the Mediterranean, and he has procured it in appreciable quantity from the ashes of the sea-weeds that furnish iodine. He has likewise detected its presence in the ashes of some animals, especially in those of the *Janthina violatea* one of the testaceous mollusca. At common temperatures bromine is a liquid, the colour of which is blackish-red when viewed in moss, and by reflected light, but appears hyacinth-red when a thin stratum is interposed between the light and the observer. Its odour, which somewhat re-

sembles that of chlorine, is very disagreeable, and its taste powerful.

Indigo. (Exhibitors 67, 68.)—Indigo may be said to be a rare production of the vegetable kingdom, it hitherto having been found only in a small number of species belonging to the genera *Indigofera*, *Isatis*, and *Nereum*; but it is almost exclusively from the first of these that the indigo of commerce is extracted. The species of indigofera are leguminous plants, herbaceous or shrubby, with alternate and generally pinnate leaves, and small blue, purple, or white flowers, ordinarily disposed in axillary racemes. They are very numerous in the equatorial regions of the globe. The species most cultivated are the *I. anil*, a native of tropical America, according to the latest authority, but now cultivated even in the East Indies; the *I. tinctoria* also cultivated in both Indies; and the *I. argentea*, which is the species employed in Barbary and Egypt. The *I. tinctoria* is the species most abundantly cultivated. Indigo is prepared in the following manner:—

The plant is allowed to stand until it is fully in blossom, when it is cut down with reap-hooks, tied in loads, and carried to the works, where it is deposited in strata in the steeping-vat. As soon as the vat is filled with the green plant, water is admitted sufficient to cover it, and the whole is left to digest and ferment, until the greatest part of the pulp is extracted, without letting the tender tops run to putrefaction. It is the management of this point which occasions the planter the greatest difficulty; for if he draws off the water but two hours too soon, he will inevitably lose the greatest part of the pulp; and if the fermentation runs but two hours too long, the whole is spoiled. To ascertain the due degree of fermentation, the workman draws out, from time to time, a handful of the plant; and when he finds the tops grow very tender and pale, and observes the stronger leaves change their colour to a less lively pale, he draws the liquor off without delay.

An experienced manufacturer will also form a tolerable estimate of the degree of fermentation by the grain of the infusion, of which he frequently beats a little in a silver cup. When the pulp is believed to be extracted, the infusion is drawn off into the beating-vat; after which it is treated in a manner similar to that above described. It is computed that British India supplies three-fourths of all the indigo brought into European markets.

Artificial Ultramarine. (Exhibitors 9, 33, 63.)—This very interesting preparation was accidentally discovered by Guimet, from the circumstance of a very beautiful blue colour having been observed in an alkali furnace. It is made by heating carefully carbonate of soda, sulphur, and porcelain clay. The analysis of the best specimens shows the composition of the ultramarine to be silica, soda, and alumina, with a trace of iron; the colour, in all probability, depending upon the formation of a sulphuret of iron. Everything, however, depends upon the character of the clay employed, and several nice points of manipulation, which it is impossible to describe. This colour is most extensively employed by the calico-printer and by the artist; the former preferring that variety which has a tendency towards a purple, while the artist desires that which is a pure blue without a trace of red in its composition. The true ultramarine is prepared from the lapis lazuli, the finest specimens being sold for as many pounds the ounce, as the artificial is shillings for the pound; and there is but little doubt but they are both equally permanent colours.

Naphthaline from Coal; Mineral Oil; Paraffine. (Exhibitors 5, 7.)—Naphthaline is obtained by decomposing organic substances by heat. It is obtained abundantly by rectifying coal-gas tar, and it crystallizes in white silvery plates. This peculiar compound of carbon and hydrogen is chemically interesting, from the numerous products to which it gives rise when treated with alkalies and acids.

The mineral oil exhibited is a bituminous fluid which flows in considerable quantity from a bed of coal. It is, no doubt, the result of a natural decomposition, and is exceedingly rich in paraffine, which is another of the hydrocarbon compounds.

Paraffine is an important constituent of tar, particularly that which is obtained by the destructive distillation of wood. It is white, crystallizes in brilliant plates, fuses at 111° Fahr., and may be distilled without undergoing any change. Ether and alcohol dissolve it; but it is scarcely acted upon by reagents, whence its name *parum affinis.*

No. 23 is an exhibitor of nitrate of potash and ammonia; both the muriate (sal ammoniac) and the carbonate (smelling salts) are made from the ammoniacal liquor of the gas-works.

Colouring Matters and Preparations used for Dyeing. (9.) —A considerable variety of preparations are exhibited, many of them new, for producing colour upon cotton linen, silk, and wool: these merit a close examination.

We have already referred to the uses of the orchilla weed (10): the following remarks on its use in dyeing, are of interest:—

With respect to the application of the colouring matters, prepared from the orchilla weed, it may be stated that where great bloom is required by the dyer, orchil is generally preferred, though the colour is perhaps not quite so permanent as that of cudbear.

Blue orchil is used for violets and lavenders on silks, and also for the bluing of whites, being united for this purpose with soap.

Red orchil is used for purple and crimson shades; very pure and bright colours being required for silk.

Both paste orchil and cudbear are used for the dyeing of wool and worsted, in cloth, stuff, and fancy goods; sometimes alone, but more frequently as an element in compound dyes, such as in violets and lavenders with

indigo, drabs with extract of indigo and fustic, clarets and browns with peachwood, &c.

Indigo blues are sometimes dyed first with cudbear, and then bloomed with orchil, and the colour of the piece is by this means considerably improved, and is not less durable than when indigo alone is employed. Yet prejudice, with the idea of having nothing but a genuine colour, would frequently withhold the use of that which, used in moderation, is not detrimental, but decidedly useful.

Weed orchil is preferred for some purposes: by putting the weed into a pretty open bag, the colouring matter can easily be boiled without risk of the shreds of weed being introduced into the goods.

Blue liquid orchil is used for staining leather and wood, and mixed with lime for colouring the walls of houses.

Concentrated liquid orchil is used by the woollen printer for chocolate and dahlia shades.

Many attempts have been made to accomplish the dyeing and printing of cotton with these colouring matters.

It was thought possible, by means of acids, so to alter the nature of cotton as to render it similar in character to animal wool: the term *animalization* has been applied to this process. And it may be as well perhaps to state here that vegetable substances generally exhibit little or no disposition to unite with these dyeing matters. The treatment by acids did not succeed, the cotton refusing to undergo the desired metamorphosis.

The plan of M. Brocquet, as exhibited at the last French Exposition, attracted some attention. It consisted in preparing the piece on the warp with albumen or solution of casein, which then took the colour tolerably well; but the colour was not sufficiently permanent, and would not bear washing.

Lately, Mr. Thomas Lightfoot, of the Broad Oak Print Works, Lancashire, has discovered that cotton prepared with oily matters, as in the Turkey-red process, exhibits

an extraordinary attraction for the orchil colour. The beautiful dahlia shades printed by Messrs. Hargreaves Brothers and Co. are obtained in this way. The process is patented.

On thin muslin the effect is perhaps not sufficiently intense; but it is probable that by the application of the improved process for condensing the fibres of cotton, as recently patented by Mr. John Mercer, in conjunction with the process of Mr. Lightfoot, that this desideratum might be obtained.

Stannates, with Models of Apparatus. (7.)—The common *tin-stone*, the usual ore of tin in Cornwall, is a peroxide of that metal. By acting upon this by an alkali, it plays the part of an acid, and combines: thus is produced those very beautiful crystals of stannate of soda exhibited; which preparation is now employed most extensively as a mordant by the calico-printers.

Lactine—Sugar of Milk. (100A.)—This remarkable substance is obtained only from the milk of the mammalia. It is procured by evaporating *whey* to a pellicle, and setting it aside to cool, when the sugar crystallizes in square prisms. Those exhibited are remarkably fine specimens: it is composed of carbon, 24; hydrogen, 24, and oxygen, 24. By being digested with dilute sulphuric acid, it is converted into grape sugar; and its reactions are peculiar. For these any good chemical treatise is referred to. A peculiarity in the specimens exhibited is, that the crystallization was effected at three different temperatures, 160°, 120°, 56° Fahrenheit, in the dark.

Stained Woods. (Exhibitors 35, 39, 65, 74.)—Solutions of chemical compounds have here been made to penetrate the wood. Many of them are effective; the natural grain of the wood being preserved, notwithstanding the artificial colour given to it. Many of these would form beautiful substitutes for the labours of the grainer of wood.

Pigments. (Exhibitors 1, 28, 48, 78, 92.)—Beyond the colours already noticed in this Class, there are a few others.

The mineral blue colours are for the most part compounds of iron and cyanogen. They are prepared by the addition of a salt of iron to a solution of ferrocyanide of potassium, usually known by the name of prussite of potash, as already described. The colours thus obtained are known in the trade under the names of Chinese or Prussian blues—the only difference existing between the two being occasioned by the admixture of a certain portion of alumina with the latter kind. The alumina in this instance merely serves to dilute the colour and give it additional weight. These blues, besides being extensively employed by painters and artists, are used in large quantities by paper-makers and paper-stainers. Most of the greens exhibited are salts of copper; there are, however, some exceptions. Brunswick green is prepared by mixing together in variable proportions the yellow chromates of lead and Prussian blue—more or less sulphate of barytes or Paris white, being at the same time added, in accordance with the shade and strength of the colour intended to be made.

Among the salts of copper may be mentioned Scheele's, or emerald green, the verditers, and natural green, or ground malachite. Scheele's green is an arsenite of copper, prepared by adding a hot solution of arsenite of soda to a nearly-saturated solution of sulphate of copper, which for this purpose should be perfectly pure. When the precipitation of the copper salt has been completely determined, a certain portion of acetic acid is added to the mixture: this liquid has the property of greatly adding to the brilliancy of the colour produced; but in what precise way this is effected, chemists have not, as yet, satisfactorily determined. The colour obtained is a beautiful and delicate green tint, but possesses little body. This pigment, like most of the other compounds of copper and arsenic, is of a highly-poisonous nature, and the most lamentable results have in more than one instance resulted from its employment in the colouring of the fancy sweet-

meats, &c. Verditer, although of a green colour, is far less delicate in tint than that just described: it is made by the addition of milk of lime to a solution of sulphate of copper, and is chiefly employed by paper-stainers in the preparation of the commoner kinds of coloured papers.

Vermilion is among the finer colours. This is a compound of sulphur and mercury, which occurs in nature as a common ore of quicksilver, cinnabar, and is prepared by the chemist as a pigment, under the name of vermilion. This substance is a bisulphuret of mercury; and being, on account of the beauty of its colour, extensively employed in painting, making red sealing-wax, and for many other purposes, the preparation of the artificial variety has become the object of an extensive and important manufacture.

The usual process is to heat together, in a large earthenware or iron pot, a mixture of sulphur and metallic mercury, in the proportion of 150 of the former to 1,080 of the latter. When vermilion is prepared by sublimation, it forms into masses of considerable thickness, concave on one side, and convex on the other, of a needle-form. On being finely pulverised, however, it assumes a lively red colour, of which the brilliancy, in a great measure, depends on the fineness of the state of division to which the sulphuret is reduced.

Lakes—Lac Dyes. (Exhibitors 68–92.) Under this title are comprised all those colours which consist of a vegetable or animal dye, as from madder, safflower, and cochineal, combined by precipitation with a white earthy base, which is usually alumina. The method of preparation is to add to the coloured infusion a solution of common alum, or a solution of alum saturated with potash. At first only a slight precipitate falls, consisting of alumina and the colouring matter; but on adding potash a copious precipitation ensues of the alumina associated with the dye. When the dyes are not injured, but on the contrary im-

proved, by the presence of alkalies, the above process is reversed: the decoction of dye-stuff is made with alkaline liquors, and after it is filtered a clear solution of alum is poured into it. A third process is applicable only to substances having a great affinity for subsulphate of alumina: this consists in agitating recently-precipitated alumina with a decoction of the dye.

Yellow lakes are coloured either with decoctions of French or Persian berries, quercitron bark, or annatto; the red and scarlet lakes are cochineal, or madder; and a kind of brown lake is prepared from the liquor obtained by the maceration of finely-chopped Brazil-wood.

Carmine is merely another name for an exceedingly brilliant variety of lake, in which the colouring principle is derived from cochineal, which is the female of a species of insect very abundant in Mexico, where it is found adhering in large quantities to the young shoots of the cactus opuntia or nopal tree.

The insects are collected by women, who brush them off the plants with the tail of a squirrel; they are then killed by being thrown into boiling water, or placed in ovens and dried in the sun. Those killed by the latter method, called in commerce "silvery," fetch the highest price—the white powder covering the insect being still retained. The quantity of the cochineal insect exported from South America does not amount to less annually than 500,000*l.*

Kermes—the scarlet grain of Poland—lac-lake, lac-dye, and all the modifications of gum-lac, are the secretions of insects, or the insects themselves dried. Kermes is the *Coccus illicis*, and is found abundantly on a species of evergreen oak (*Quercus coccifera*). The scarlet grain of Poland is the *Coccus Polonicus*, and is found on the roots of a plant growing abundantly in the north-east of Europe. Lac is a secretion from a species of coccus inhabiting India, where it is found in abundance. In its native state it is called *stick-lac* — when separated from the twig and powdered, *seed-lac*, and when melted *shell-lac*. Lac-lake is the colour-

ing matter of *stick-lac*, precipitated from an alkaline lixivium by means of alum.

Dried Pharmaceutical Indigenous Plants, in glass vessels, with extracts, powders, &c. (90.)—The colour, aroma, and active principles of the plants are admirably preserved: the blossoms and leaves of many of them are seen fully expanded, and look quite fresh, showing the great care which has been bestowed on their preparation. There are also some fine specimens of pharmaceutical extracts, prepared with such care as always to insure one uniform strength.

The powders of *Bonum digitalis*, and other plants, are very fine preparations, and the roots, &c. are well preserved. The exhibitor is well known for the excellence of his pharmaceutical preparations. The specimen of *dried immature* poppy capsules, cut and dried before being injured by the effects of the atmosphere by standing too long, as they usually are, are worthy of attention. The extract and syrup made from them are always of one *uniform strength*, and possess very active properties. It too often happens that the medicinal properties of the plant are injured by the careless manner in which they are collected and preserved. This is a subject of much importance to the medical man.

Bicarbonate of Magnesia. (Exhibitors 51, 87.)—If carbonate of magnesia is placed in water, it is found to be nearly insoluble; but if carbonic acid is forced through the water, it is dissolved by the agency of the carbonic acid in excess: this constitutes the fluid magnesia.

English Rhubarb. (98.)—Of this peculiar variety Dr. Pereira gives the following interesting account:—"This is the produce of *Rheum rhaponticum*, cultivated in the neighbourhood of Banbury, in Oxfordshire. The history of this rhubarb is not a little curious. It appears that Mr. William Hayward, an apothecary at Banbury, was the original cultivator of rhubarb in that locality. From his own statement it appears that he began to cultivate it about the year 1777. In 1789 he obtained a silver medal

and in 1794 a gold medal, from the Society of Arts, for the cultivation of what he terms the 'true Turkey rhubarb,' the plant for which the Society offered the premium being the '*R. palmatum*, or true rhubarb.' Mr. Hayward died in 1811, and his plants were purchased by the father of one of the present cultivators. At present there are three cultivators of Banbury rhubarb, viz., Mr. R. Usher, of Overthorpe and Bodicott; Mr. T. Tristian, of Milcombe (joint exhibitors); and Mr. E. Hughes, of Neithorp. These parties grow altogether about 12 acres of rhubarb. Only one species is cultivated, and that I find to be *R. rhaponticum*. . . . Mr. Usher states that no other species was ever cultivated at Banbury; and that he cannot produce English rhubarb from the 'giant rhubarb' or any other sort. The rhubarb is obtained from roots of three or four years old; they are dug up in October or November, freed from dirt, deprived of their outer coat by a sharp knife, exposed to the sun and air for a few days, and dried on basket-work in drying-houses heated by stone pipes or brick flues."

Chloroform. (Exhibitors 93, 104.)—This preparation has assumed great importance from its peculiar properties. Its narcotic or anesthetic powers are very great. If a sponge or handkerchief, moistened with chloroform, be held under the mouth and nose, so that the inspired air shall become mixed with a large portion of the chloroform vapour, total insensibility supervenes after a few minutes; insensibility to pain accompanies this state, and hence its use during painful operations. It is prepared by distilling alcohol from chloride of lime mixed with water: it is consequently a compound of carbon, hydrogen, and chlorine.

The Pharmaceutical articles exhibited by the London druggists (117) and others, 79, 81, 83, 85, 90, 93, 94, 95, 96, 97, 102, 103, 108, 110, 114, 115, 116. In the collection by the London druggists will be found some very interesting specimens of roots, barks, leaves, seeds, &c., used medi-

cinally; and some animal productions, as castor and cod-liver oil, cantharides, &c., will also be found. It is quite impossible to describe each article exhibited, and useless to make any selection. A careful examination of the specimens is recommended to those who are interested in the subject, and reference to the Materia Medica of Dr. Pereira for information.

Miscellaneous.—Under this general head we would refer to the series of bank checks (36) on tinted paper, the object being to produce a change of colour when any acid is applied for the purpose of removing the ink for any fraudulent design; a chemical production (101) to impart "a silvery hue to drawings"—an effect, we believe, from the specimens exhibited, to be produced by washing the drawings with a solution of a salt of lead; refined saltpetre (19), from the East Indies; royal premier blacking (22); shaving cream (25); and myrrhine aids to the digestive organs (105)—show the varieties which are grouped under this class.

Attention should be particularly directed to the beautiful masses of crystals which are in the Main Avenue, and at the bottom of the stairs leading from that section of the South Gallery which includes the Chemicals. As illustrations of the scale on which the substances exhibited are manufactured, these are very remarkable.

Process for Cleaning Deeds, &c., injured by Fire. (26.)—The specimens exhibited show an indenture that was taken from the ruins of the great fire at Lincoln's Inn, January 14th, 1849. The restored half (without having been separated from the dirty half) is cleansed, and flexibility imparted to it; it had been hard, horny, and brittle, from the effects of the fire and water—any ordinary attempt to open it, breaking it. The writing has sustained no injury.

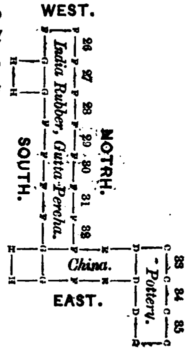
Two leaves of a book, and two leaves of the 'Jurist' newspaper, and other portions of parchment, taken from the same fire, which have been injured by fire and water, &c.

A map and several engravings, injured by age, smoke, mildew, water, and dirt, &c., the whole having been in the dirty state—the halves cleansed.

The exhibitor draws the attention of the public to the advantages attending the process discovered by him, of cleaning, restoring, and repairing paper and parchment injured by different causes, without any detrimental effect to either the paper, parchment, or ink; on the contrary, his process imparts flexibility to parchment, and strength to paper; parchment injured by fire, and other causes, becoming so brittle that it was impossible to open it, and paper losing its strength. The process has been tested, and employed on many of the documents recovered from the great fire at Lincoln's Inn, giving entire satisfaction.

Class XXVIII.—Manufactures from Vegetable and Animal Substances.

Position of Class.—*Numbers referring to Pillars, North Gallery, between* F. G. 26 *and* 32, *the Porcelain Group, Class* 25, *being to the East of it and the Cutlery, Class* 21, *to the West.*



The whole group is so small that it requires no subdivision.

Caoutchouc Manufactures. (Exhibitors 72, 73, 76, 77, 78, 81, 82, 83.)—The variety of forms under which India-rubber is exhibited sufficiently testify to the value of this curious substance, as an article adapted for manufactures. Caoutchouc is the milky and resinous sap found in many plants, but especially derived from species of *Siphonia*, a genus belonging to the Spurge family; of *Urceola* and *Vahea*, genera of the dogbane family, and certain trees of the fig kind, especially *Ficus elastica*. The best caoutchouc is that procured from a *Siphonia*, a tree indigenous in Central America. The *Urceola elastica* is a creeping shrub, a native of the Indian Islands; and the *Ficus elastica*, a tree of the mainland of India and the neighbouring countries to the eastward. The South American kind was that first known in Europe; but its origin and uses were not understood until the early part of the last century. The bottles of India-rubber had been previously regarded merely as curiosities. They are made by spreading the milky juice, as it flows from the wounded tree, on moulds of clay, sometimes fantastically shaped. There are some curious examples in the Exhibition. These are dried over a smoky fire, and repainted

with fresh layers of juice, which are successively dried until sufficient thickness be attained. The large solid flat masses are prepared in a different manner. The product so procured attains different degrees of solidity. It is applied to manufactures in various ways. It may be dissolved in some menstruum, such as naphtha, or spirits of turpentine, (in which state it is called varnish,) or with a small quantity of solvent in the state of dough, it is spread upon cloth, from which it may be stripped, and forms sheets 50 inches wide and 100 feet long; or sheets may be made by kneading the rubber in powerful machinery, and, whilst hot, forcing it into oblong blocks, from which veneers or sheets may be cut. But the greatest improvement in its treatment and manufacture was the discovery of vulcanizing, a term applied to a peculiar amalgamation with sulphur by means of heat, when it obtains new properties, and retains any form that may be given to it by pressure during the process of vulcanizing, a discovery made by Mr. Thomas Hancock in 1843. "A sheet of caoutchouc immersed in melted sulphur absorbs a portion of it, and if continued at a higher temperature it undergoes some important changes in many of its characteristic properties. It is no longer affected by climatic temperature; it is neither hardened by cold, nor softened by any heat which would not destroy it. It ceases to be soluble in the solvents of common caoutchouc, while its elasticity becomes greatly augmented and permanent. The same effect may be produced by kneading sulphur into caoutchouc by means of powerful rollers, and then subjecting the compound to similar degrees of heat."—*Brockedon*. The collections exhibited display the material in its raw state, and variously combined with cloths, and vulcanized. Among the more curious applications of it may be noticed the purchases for the raising and sustaining weights, and obtaining pressure. The elastic bow-strings (72), India-rubber portable boats (81), and shower-baths (83), show some of the numerous uses to which it has been turned by

Mackintosh and Co. (76). The series of specimens of South American caoutchouc (78) are well worthy of study. This substance was not imported into Britain to any considerable extent until within the last twenty years. According to the exhibitor of the Liverpool imports, 500 tons of it were brought from Maranham to Liverpool in 1850, being nearly five times the amount imported during the preceding year.

Various manufactures of elastic cloths, &c., are exhibited, into most of which caoutchouc enters.

Gutta Percha Manufactures. (Exhibitors 85, 86, 87, 90.) —A very few years ago this substance, now so useful, was either unknown or regarded as a mere curiosity, and the tree from which it was derived had not been discovered. We now know that it is a kind of caoutchouc, the inspissated milky juice of the *Isonandra gutta*—found between the bark and the wood—a tree of slow growth, belonging to the natural order *Sapotaceæ*, and indigenous in the Indian Archipelago. This substance becomes soft in boiling water, and may be moulded into any shape, and converted into most useful vessels, tubes, and instruments, that are not intended to be used at a temperature above 50°. It is manipulated when soft with great facility, and can be pressed in moulds into any required shape. Combined with colouring matter, it may be converted into imitations of various substances, and even metals. Besides numerous ornamental applications, others of a more useful character may be noticed—such as carboys for holding acid, wash-basins, ear-trumpets, whips, stethoscopes, tubes for inverting the wires of electric telegraphs, hats, dolls, and even into shoes for horses and constables' staves.

Vegetable Ivory. (Exhibitors 28, 47.)—The curious and beautiful substance out of which the ornaments here exhibited are carved, is the seed of a species of palm, the *Phytelephas*, a member of the screw-palm tribe. It is commonly called, in Peru, the Taqua, and also Negro's head. The value of the substance of the seed for trinket-making

has been long known to the natives of the region through which the river Magdalena flows, where these trees are abundant. It is only within a comparatively short time that it has been employed for turning in Europe. The hard white interior of the seed is the albumen stored up for the use of the embryo plant. At first this is a transparent fluid, but eventually, after becoming milky and opaque, it becomes solidified. When the seed germinates, the hard albumen becomes gradually changed as it is absorbed by the embryo plant. Handles for walking-sticks and umbrellas, buttons, &c., are made out of it, as well as very beautiful toys.

Manufactures of Cocoa-nut Fibre. (Exhibitors 39, 40, 43.) Coir, or fibre of the husk of the cocoa-nut, is a substance highly valuable for manufacturing processes. The husk is the main body of the fruit, the part we eat being properly a portion of the seed, its albumen, similar to the substance used for carving in the vegetable-ivory nut, also the seed of a palm. The husk is pulled to pieces and the fibrous portion completely separated from the rest of its substance in order to make coir. It is then one of the strongest vegetable substances known, and is largely used in the East for the manufacture of ropes and cables, and even of a coarse sail-cloth. Here we have it converted into mats, coarse and fine, and even into ladies' bonnets. In an uncombined state it is used for the stuffing of mattresses, and converted into a sort of vegetable hair. One case (40) shows all the stages of conversion of the cocoa-nut husk into coir. Manufactures are shown (39) made from a mixture of coir and Manilla hemp. The latter substance is the fibre of *Musa textilis*, a species of plantain, and not to be confounded with our hemp *Cannabis sativa*, a plant of a very different tribe.

Brushes (Exhibitors 3, 21, 29, 34, 52, 55A, 58, 61, 67, 68, 161, 181) are displayed in great number and variety. Not a few are exhibited on account of peculiarities in the mode of fixing the bristles. Among them are some (58) described

as cheap and durable, remarkable for being constructed of quills split into bristles, and others in which the material used for the same purpose is cocoa-nut fibre.

The various articles for the toilet are here exhibited (Exhibitors 81, 55, 84, 177), and are remarkable for neatness of workmanship. Here too are wigs and various arrangements of hair (Exhibitors 22, 62, 64), and combs made out of different materials (Exhibitors 18, 65, 152), but especially of tortoiseshell. This substance is the outer plating of the carapace of *Testudo imbricata*, a species of sea-turtle. It is separated from the bony portion by heating, and softened and moulded into various shapes by immersion in boiling water. The largest animals furnish the best shell.

Tortoiseshell is shown, also, inlaid with mother-of-pearl in boxes and similar articles. (Exhibitors 131, 132.) The effect arising from contrast of colour and texture is very pleasing. In these inlaid works, the mother-of-pearl varies in colour, some portions being of a rich lustrous green and purple, others more pale and pearly. The former are used for framing the latter, and are derived from the shells of *Haliotis*, or ear-shell, of New Zealand; the latter are mostly obtained from the shells of *Aviculæ* or pearl-oysters.

Cork (Exhibitors 124, 125, 126) is the outer layers of bark of the *Quercus suber*, a species of oak indigenous in the South of Europe. The tree is usually not ready for stripping until twenty-five years of age or more, after which time it may be barked once every eight or ten years. The sheets of cork are scorched on both sides and pressed when hot between flat planks, in order to make the texture compact. The quality varies very much, according to soil or age of the tree, or interval between the operations of barking. It is a curious fact, that the use of cork for bottle-stoppers, now so universal, is a practice that originated long after this material was well known and variously applied, and that the ancients do not seem to have adopted

it for so obvious a purpose. Among the purposes to which it has been applied in the Exhibition is the making of hats of exceeding lightness and apparently excellent quality.

Sponges (117), though properly raw materials, are exhibited here. Those displayed are from the Archipelago and the Bahamas. The finer kinds are chiefly Turkey sponges.

Sponges are found inhabiting all seas, and living at all explored depths; but the greater number of kinds are of no use for commercial purposes, their framework consisting of spiculæ, either calcareous or silicious. Those only are chosen that have a horny skeleton. There are many varieties even of these, and the sponges exhibited from Turkey are specifically distinct from those procured from the Bahamas. The coarser and finer sorts, the former being the "grass" and "honeycomb" sponges of commerce, are also distinct species. The Turkey sponge grows, attached to rocks and stones, in from three to thirty fathoms under water. One of the specimens exhibited is attached to a vase, and was so taken up off the Island of Rhodes. When alive it is usually of a dark, often nearly black, colour, especially on its upper or spreading portion. The sponge-divers go to work between April and October, and can remain under water from one to three minutes. They carry a netted bag attached to a hoop, suspended round their necks, and stow away the sponge when they have torn it from the rock. The sponge is then dried in the sun, after being cleaned in sea-water, its fleshy matter being stamped out by the divers' feet.

Among the *Wood-work* in this department are mouldings made by machinery.

Wood Carving. (Exhibitors 98, 127.)—Veneered mouldings (165) and sundry specimens of ornamental carving, including a pulpit and other church furniture, and a model to scale of the choragic monument of Lysicrates (99).

Basket-work is shown in great variety, and plaiting in

straw and chip. A curious and not inelegant use of straw is shown in a chandelier constructed of that material (41). There is also much work of this description among the collection of miscellaneous articles, ingeniously made by the blind. Those from the School of Industry for the Blind in Bristol (30), and from the School for the Indigent Blind, St. George's Fields, Southwark (100), may be especially noticed. Very curious, too, are the miscellaneous articles (186) shown by Mary Jane Cannings, of Bath, a person who is stated to be suffering from the terrible infirmity of being at once blind, deaf, and dumb.

There are numerous examples of articles turned in ivory, wood, and cannel coal. (Exhibitors 15, 28, 45, 48, 95, 99, 158, 163, 164, 167, 170, 175.)—Ivory is the substance of the tusk of the elephant and some other mammalia, especially the hippopotamus (the tusks of which are often referred to the sea-morse in commerce), morse, narwhal, and spermaceti whale. That of the elephant is most used and valued, and the number of these animals yearly destroyed to supply the demand must be prodigious. The ivory of the morse or sea-horse is said to be valued by dentists for the making of artificial teeth, but, in this case, hippopotamus' ivory is probably meant.

Liverpool Collection of Imports.—In a long glazed cabinet is displayed a collection of the imports, chiefly of raw produce, into the port of Liverpool during the last five years. This most interesting and instructive little museum has been arranged with much skill and judgment by Mr. T. G. Archer. The substances exhibited are carefully labelled, their mercantile appellation and scientific name, whenever it could be ascertained, the locality whence imported, their uses, and frequently the quantity imported during the past year, all being stated. The specimens are classified in groups according to the uses to which they are applied. Among the woods used for building or ornament are several of which the true origin is uncertain or unknown. There is a fine series of dye-

woods. Among the canes and reeds is placed a gutta percha walking-stick, such as is used in the countries whence that substance is procured. The fibrous substances are especially interesting. Among the various kinds known in commerce as hemps or flaxes are exotic fibres derived from very different plants. Of these are the "Manilla hemp," the fibre of a plantain, the *Musa textilis*, used for cordage, of which 192 tons were imported in 1850; jute, the fibre of *Corchorus capsularis*, used for mixing with hemp, and even with silk, for the sake of cheapness, of which no less than 12,216 tons were imported in the same year; Piassava, a vegetable hair from a Brazilian palm, the *Attalea funifera*, used for making sweeping-brushes, and imported to the extent of 300 tons. China grass, the *Boehmeria nivea*, brought from Hongkong and Canton, used for making linen, and imported to the extent of 150 bales in 1850, being twice the quantity of the preceding year; sun, from India, used for rope-making—of this material 81 tons were imported in 1850, and none the preceding year; and coir, of which no less than 1,100 tons, in the form of rope, were brought into Liverpool last year. Several of these are substances that have come into use within a few years back. It is curious to note, in this case, others only just appearing, such as the Brazilian jute, a fibre of unknown origin, the fibres of the *Corypha cerifera*, or Brazilian palmetto, the vegetable silk derived from *Chorisia speciosa*, a South American plant of the mallow tribe. A like experimental import is the vegetable tallow derived from the *Croton subiferum* of China, not yet applied to any purpose, but apparently possessed of capabilities. Four to five cwts. of the vegetable wax from the Brazilian palmetto are annually imported for the making of candles. The series of cottons, teas, sugars, seeds, grains, spices, and fruits, are all of much interest. It is curious to note that as much as 26,500 bushels of Brazil nuts, the seeds of *Bertholletia excelsa*, a great tree of the myrtle tribe, were

imported into Liverpool last year, and as many as 400 quarters of ground nuts, the seed-pods of *Arachis hypogea*, a West African plant. Among the animal products are many interesting skins. Of those procured from America it is worthy of remark that no fewer than 2,000 opossums' skins (*Didelphis virginiana*), and 1,500 of the *Myopotamus coypus*, were imported last year. Very curious, too, is the fact that vast supplies of horse hair and ox horns are now derived from the New World, where the animals that furnish them were introduced with the conquest. Invertebrate animals do not yield many articles of commerce; here, however, we find several of consequence. Thus, of the great conch-shell, *Strombus giganteus*, from the Bahamas, 130,000 are stated to be imported annually for the purpose of being cut into inferior cameos or used in the manufacture of porcelain. Of the *Avicula* or mother-o'-pearl shell of Manilla, 30 tons were imported in 1850, 20 tons of that from the Society Isles, and 200 tons of that from Panama. From this collection it appears many hundred-weight of cuttle-fish bones are imported annually from the Levant.

The Hull Collection of Imports in the North Transept Gallery, near the Organ, is also very interesting, though not of the same extent. A great part of these are the productions of Russia and other northern countries, or of the countries around the German Ocean. In one case is a set of the implements used in the Greenland whale fishery.

Ornamental Woods.—The interest which attaches to the very numerous collection of woods belonging to this class, which are exhibited against the South Wall of the Building in Class I., numbered in Class IV. 135, renders no excuse necessary for the introduction in this place of the following classification of specimens of foreign hard woods for cabinet-work, turnery, dyeing, and machinery; also of elephants' tusks, sea-horse teeth, mother-of-pearl shells, &c.

Names.	Natural family.	Places of Produce.	Purposes.
1. Amboyna, or Kiabooka (*Pterospermum indicum*)	Buttneriaceæ	E. Indies, Borneo, Amboyna	Cabinet-work.
2. African black wood (Cocobolo prieto).	?	Africa, Madagascar, &c.	Turning.
3. Angica	?	The Brazils	Cabinet-work and turning.
4. Barwood (*Baphia nitida*)	Leguminosæ	Africa (W. Coast)	Dyeing and turning.
5. Beefwood, or Bully tree (*Robinia panacoco*).	"	Guiana (Demerara).	Machinery and turning.
6. Botany Bay Oak (*Casuarina stricta*).	Casuarineæ	N. S. Wales	Turning and brush-making.
7. Boxwood (*Buxus balearica*).	Euphorbiaceæ	Turkey	Turning, machinery, and wood engraving, &c.
Boxwood (*Buxus sempervirens*).	..	England, Spain, &c.	
Boxwood	..	America	Turning.
Boxwood	..	East Indies	
8. Brazil wood (*Cæsalpinia Brasiliensis*).	Cæsalpineæ	The Brazils	
9. Braziletto (*Cæsalpinia Bahamensis*).	"	Jamaica and the Bahamas.	Dyeing and turning.
10. Cam wood (*Baphia nitida*)	Leguminosæ	Africa, West Coast	
11. Camphor wood (*Camphora officinalis*).	Lauraceæ	China, Borneo, &c.	Cabinet-work.
12. Canary wood (*Laurus indica*)	"	The Brazils, &c.	Cabinet-work and turning.
13. Cedar (pencil) (*Juniperus virginiana*).	Coniferæ	The United States	Pencils and cabinet-work.
14. Cedar (Cuba) (*Cedrelaodorata*)	Cedrelaceæ	West Indies, Havana	Cabinet-work.
15. Cocus wood (*Amerimnum ebenus*)	Leguminosæ	Jamaica	Turning, &c.
Cocus wood	..	Cuba	
16. Coromandel or Calamander (*Diospyros hirsuta*).	Ebenaceæ	East Indies (Ceylon, Manilla, &c.)	Cabinet-work and turning.
17. Ebony (black) (*Diospyros melanoxylon*).	"	Africa, W. Coast	
Ebony (black) (*Diospyros ebenum*)	"	Mauritius and Madagascar.	Turning and cabinet-work.
Ebony (black) (*Diospyros ebenaster*)	"	Ceylon	
Ebony (black) (*Diospyros melanoxylon*).	"	Bombay, &c., Sumatra, &c.	
18. Ebony (Green) (*Amerimnum*) *ebenus*).	Leguminosæ	Jamaica and the Bahamas.	Dyeing and turning.
19. Fustic (*Maclura tinctoria*)	Moreæ	W. Indies (Cuba, also Savanilla).	
Fustic (*Rhus cotinus*).	Anacardiaceæ	Ionian Islands (Zante.)	Dyeing.
20. Hickory (billets) (*Carya alba*)	Juglandeæ	The United States	Handspikes, fishing-rods, &c.

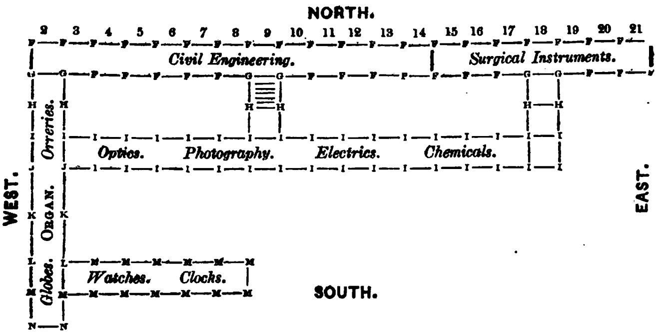
21. Ironwood (*Sideroxylon, &c.*)	Sapotaceæ	East Indies	Machinery and turning.
22. Jackwood (*Artocarpus integrifolia*)	Artocarpeæ		Cabinet-work and turning.
23. Kingwood	?	The Brazils	Turning and cabinet-work.
24. Lancewood spars (*Guatteria virgata*)	Anonaceæ	West Indies (Cuba, Jamaica).	Gig shafts, archery bows.
25. Letterwood, or Snakewood (*Brosimum aubletii*).	Artocarpeæ	Guiana and the Brazils.	Turnery and archery bows.
26. Lignum vitæ (*Guaiacum officinale*)	Zygophylleæ	West Indies (St. Domingo, Jamaica, Porto Rico, Cuba, Honduras, the Bahamas).	Sheaves for ships' blocks, turning, and machinery.
Lignum vitæ (*Metrosideros*)	Myrtaceæ	Australia	Turning.
27. Logwood (*Hæmatoxylon campechianum*)	Leguminosæ	West Indies, also Central America	Dyeing.
28. Madagascar red wood	?	Madagascar	Turning and cabinet-work.
29. Maple (Bird's-eye and Rock) (*Acer saccharinum*).	Acerineæ	North America	Cabinet-work.
Maple (Russian) (*Acer tataricum*)	”	Siberia, &c.	
Maple (English) (*Acer campestre*).	”	England	
30. Nicaragua wood (*Cæsalpinia Hæmatoxylon, &c.*)	Cæsalpineæ	Central America, &c.	Dyeing.
31. Nutmeg wood (*Areca catechu*).	Palmæ	The Brazils (Para)	Turning and cabinet-work, umbrella and parasol sticks, &c.
32. Palm-tree (black) (*Cocos niepere*)	”	East and West Indies	
Palm-tree (red and brown).	”		
Palm-tree (prickly brown) (*Cocos guianensis*)	”		
33. Partridge wood (brown and red)	?	The Brazils and West Indies	
34. Pheasant wood	?		
35. Princes wood (*Cordia gerascanthus*)	Cordiaceæ	West Indies, (Jamaica).	
36. Purple wood (*Copaifera rubiflora*)	Leguminosæ	The Brazils and West Indies	Turning and cabinet-work, umbrella and parasol sticks, &c.
37. Queen wood, or Jugeca wood (*Laurus chloroxylon.*)	Lauraceæ		
38. Red Sanders wood (*Pterocarpus santalinus*).	Leguminosæ	East Indies (Calcutta, &c.)	Dyeing and turning.
39. Rosewood (*Triptolœmea*)	”	The Brazils (Rio de Janeiro & Bahia)	Cabinet-work, turning, and brush-making.
Rosewood *Amyris balsamifera*	Amyrideæ	Honduras, &c.	
Rosewood (*Dalbergia latifolia*)	Leguminosæ	East Indies	
40. Rosetta wood	?		

Names.	*Natural family.*	*Places of Produce.*	*Purposes.*
41. Sabicu	?	Cuba	Ship-building and furniture.
42. Sandalwood (*Santalum album*)	Xantalaceæ	East Indies	Perfumery and cabinet-work.
43. Sapanwood (*Cæsalpinia sapan*)	Cæsalpineæ	East Indies	Dyeing.
44. Sapodilla (*Fagara pterota*)	Xanthoxyleæ	Honduras	Machinery and turning.
45. Satinwood (*Chloroxylon swietenia*)	Cedrelaceæ.	East Indies	Brush-making, cabinet-work, and turning.
Satinwood (*Chloranthus*)	Chloranthaceæ	West Indies (St. Domingo, Porto Rico, and the Bahamas).	
46. Tulipwood	?	The Brazils	Cabinet-work and turning.
47. Walnut wood (*Juglans regia*)	Juglandaceæ	Italy and Belgium	Cabinet-work and gun-stocks.
48. Yew tree (*Taxus baccata*)	Coniferæ	England and Spain	Archery bows and turning.
49. Zebra wood (*Omphalobium Lamberti*)	Connaraceæ	The Brazils	Cabinet-work and turning.
An elephant's head, with tusks and grinders complete.	. .	Africa W. Coast	
Elephants' tusks	. .	Africa—Camaroon, Gold Coast, Angola, and The Cape.	Cutlery, turning, carving, &c.
Elephants' tusks	. .	Calcutta, East Indies and Alexandria	
Elephants' grinders	. .	Africa	
Sea-horse, or Hippopotamus, teeth (curved and straight).	. .	East Indies and Africa	Dentists and turning
Sea-cow, or walrus teeth			
Sea-unicorns' horns	. .	Hudson's Bay	
Mother-of-Pearl shells (white edge)	Shells of *Avicula margaritaceæ* & other species.	Sincapore	Button-making, turning, and fancy work.
Mother-of-Pearl shells (yellow)		Manilla	
Mother-of-Pearl shells (black)		Tahiti	
Mother-of-Pearl shells (Bombay)		Bombay	
Mother-of-Pearl shells (Buffalo)		S. America	
Coquillo nuts (*Attalea funifera*), a kind of palm tree, which yields the fibres now in use for coarse brooms, &c.	*Palmæ*	Brazils	Turning.
Corozo, or Coruseo nuts (*Phytelephas macrocarpa*).	"	Colombia	

Class X.—Philosophical, Musical, Horological, and Surgical Instruments. Division I.

Situation of Class 10.—*It occupies the Western End of the Galleries. From* L. M. 2 *to* 8 *in the Central South Gallery; from* M. 2, 3 *to* F. 2, 3, *at the Western End, in front of the Large Organ; from* I. J. 2 *to* 18, *in Central North Gallery, and from* F. 15 *to* 21, *in the North Gallery.*

Position of Groups.—Numbers referring to Pillars.—Clocks and Watches will be found in the Central South Gallery, M. 2 to 8.—Globes, Orreries, &c., North-West Gallery, 1, 2, 3.—Optical Instruments, Central North Gallery, I. J. 3, 6.—Photographs, including Daguerreotypes, Talbotypes, &c. I. J. 6, 9.—Electric Telegraphs, I. J. 9, 14.—Chemical Apparatus, I. J. 14, 17.—Musical Instruments, 12 to 19.—Surgical Instruments, F. 15, 21.



South Central Gallery.

Clocks, Watches, &c.—*Turret Clocks.* (Exhibitors 55, 92, 130, 129, 679.)—The invention of clocks with wheels is ascribed to Pacificus, Archdeacon of Verona, in the ninth century, previously to which, water-clocks, and such-like

contrivances were employed to measure time. The epitaph on Pacificus is curious :—

> Horologium nocturnum nullus ante viderat.
> En invenit argumentum et primus fundaverat ;
> Horologioque carmen spheræ cœli optimum
> Plura alia graviaque pondens invenit.

Clocks appear to have been set up in churches towards the end of the twelfth century ; and there is a story of a clock being erected in Westminster Hall in 1298, out of a fine levied on a Lord Chief Justice ; and near the same time a clock is said to have been put up in Canterbury Cathedral, and another in Wells Cathedral. From these and other notices, it seems pretty clear, that the earliest clock of which the actual construction happens to have been preserved was that made for Charles V., surnamed the "Wise," in 1379, by Henry de Wyck, who was invited by that monarch from Germany, because there was no artist in Paris of the kind—and to whom he allowed a salary of six sols a day, and free lodgings in the Tower.

Clock-making was long neglected in this country. The most striking instance of neglect of horological principles was the practice of putting fans or wings to the pendulum for the supposed purpose of preventing it from occasionally swinging so far as to drive the pallets into the escape-wheel, under the influence of such a weight as was found necessary to carry the train through all the occasional impediments arising from bad cutting of the wheels, dirt, the force of the wind upon the hands, and all kinds of mechanical defects. It is a fact that, until lately, the French have been much in advance of us in this largest kind of horological engineering, and have spent much larger sums upon their public clocks, than have been expended in England. There are no less than four in Paris, which appear each to have cost about 1,000*l*., exclusive of some other expensive appendages, such as enamelled dials and the bells. There is not a clock in England which has cost anything near that sum.

The estimates for the great clock for the New Palace at

Westminster exceeds that amount; but that is to be a perfectly unique specimen.

Of late, an improved style of turret-clock manufacture has been introduced by some of the best makers, and since the erection of the clock at the Royal Exchange by Mr. Dent, which contains several contrivances never before used, many have turned their attention to the improvement of turret clocks.

The present Astronomer Royal, Professor Airy, has said, that he has no doubt that the Exchange clock is "the best public clock in the world," and that he believes it is superior to most astronomical clocks in the steadiness of its rate.

A clock consists of a train of wheels, generally four, of which the lowest, if it is an eight-day clock, turns round in about twelve hours, or requires fourteen turns to wind it up for the week, and the highest turns in a minute. The two intermediate wheels are merely required to carry off the difference of velocity between the two extreme ones, and to work the hands. The lower of these two intermediate wheels is usually made to turn once in an hour, so that the long or minute hand may be set upon its axis or *arbor*, and the second wheel has nothing to do but to reduce the multiplier of sixty, or the ratio of the velocity of the highest to that of the *centre wheel*, as the one which carries the long hand is usually called.

Among the turret clocks exhibited is an eight-day quarter turret clock (55), with compensated pendulum 8 feet long, and weighing about 2 cwt., vibrating half seconds, with pin wheel and dead escapements, but with a small recoil. All the wheels in the clock are of cast iron, except the 'scape-wheel, which is brass, of only 4 inches diameter, containing 40 pins, and turning in two minutes.

The 'scape-wheel is driven by a small spiral spring fixed to a pinion which turns on a stud, set in the same line as a 'scape-wheel arbor, and carrying one of the pivot wheels of that arbor. This spring is wound up a quarter of a

turn by the clock at every quarter of a turn of the 'scape-wheel.

The dial-work is all driven by the great wheel without the intervention of any pinion, and it is consequently very strong and capable of working four very large dials. (The dials in the Main Avenue of the Building are 7 feet in diameter.) The hands are adjustable by means of hand-screws, and a small regulating dial set on the clock; the dial is reversed in order to provide for the case of the external dial being on a level with the clock, and the hands driven directly by the prolonged arbor of the regulating dial. The hands are counterpoised outside the dials, because when the counterpoises are within, the force of the wind on the hands is not counterpoised at all; and the weight of the large hand when unbalanced tends to loosen the hand on its arbor, and so make it point beyond the true time from 6 to 12, and before it from 12 to 6.

The maintaining power for keeping the clock going while winding is of a new construction. Before winding, the maintaining weight must be raised sufficiently high to keep the clock going about seven minutes, and when wound up it can be thrown out of action immediately.

All the great wheels are set in the great frame, and the small triangular frames can be taken off without moving the great wheels and barrel, or the pendulums which may be suspended from the wall. The smaller wheels will also take out separately. The weights are hung by wire ropes, and they require a fall of about 40 feet with a single pulley. The pulleys are one foot in diameter.

The hammers are raised by cams cast on the great wheels, of such a shape as to raise them with the least friction. They are strong enough for an hour-bell of several tons weight, and quarters to correspond, though the great wheels are only 18 inches in diameter; the hammers all stand ready to fall as soon as they are discharged by the going part. The first, second, and third quarters, begin exactly at those quarters, and the fourth begins half a

minute before the hour, and the hour-hammer falls exactly at the hour.

The object aimed at in this clock is to combine the greatest accuracy of timekeeping with great strength, and the cheapest mode of construction, which is consistent with good work.

The large turret clock (130) presents evidence of mneh original genius. The frame is of a quadrangular pyramidal form, which is admirably adapted for solidity; the large wheels being placed near the base of the pyramid, and the smaller parts above them. The teeth of the wheels and pinions are all cast, except those of the 'scape-wheel; this must, of course, influence considerably the cheapness of construction. The escapement is detached, and of a novel construction; there is a detent with two arms, on an axis which has also a pinion in gear with a wheel on the same axis with the 'scape-wheel, so that the detent axis makes half a turn to release each tooth of the 'scape-wheel. The detent is held by a tooth at the end of an arm that hangs from the point of suspension of the pendulum; this arm is moved by a pin projecting from the pendulum near the end of its oscillation, and releases the detent, when the pendulum receives an impulse from an oblique surface of a tooth of the 'scape-wheel. The 'scape-wheel is impelled by a remontoire of perfectly uniform action; this consists of a weight attached to an endless chain, which is wound up every half-minute, on the release of the train, by the arm of another two-armed detent. The clock weights themselves also form part of an endless chain; but this seems to be an unnecessary refinement. The construction of the hammer by which the bell is struck is also quite new. The head of the hammer is a ball of gutta percha, by which the tone of the bell is at once brought out, unimpeded by the secondary vibrations that result from the blow of an ordinary metallio hammer. Again, the fly is superseded, and the hammer is made to perform the office of a fly. It revolves at right angles to an axis, and, in

making one revolution, acquires sufficient centrifugal force to throw the head outwards, and enable it to reach the bell.

In the South-west Gallery are two turret clocks (129), but they present no remarkable feature.

Astronomical Clocks. (Exhibitors 35, 55, 57, 60, 73.)—It is usual to call those clocks astronomical, which are used in observatories for determining the right ascension of heavenly bodies: they include every appendage which contributes to accuracy in the measurement of time, under all the changes of atmospheric temperature. Among those exhibited is, the astronomical clocks with mercurial pendulum and dead-beat escapement, which should be carefully inspected. Mercurial pendulums and dead-beat escapements are now used in nearly all astronomical clocks. The number of such, now in London, exceeds 200: about 60 of these, chiefly the property of eminent chronometer-makers, are rated on Greenwich mean time, and it is found that their performance is such as to adapt them for astronomical uses.

The rod of the mercurial pendulum is of steel, and the mercury is put in a cast-iron cylinder (in the best pendulums), screwed to the bottom of the rod. It is to be remembered that the rise of the mercury in the cylinder will be diminished by the lateral expansion of the cylinder itself, and consequently a rather greater height of mercury is required than that given by merely taking the tabular rate of expansion. The old form of mercurial pendulum was that of a glass cylinder, standing on a *stirrup*, at the bottom of the rod. The chief advantage of the iron cylinder is, that it can be made of a more regular shape, and that it takes the same temperature as the rod, and communicates it to the mercury more rapidly than the glass. Captain Kater, in his chapter on compensated pendulums, in his Treatise on Mechanics in *Lardner's Cabinet Cyclopædia*, says, he has successfully employed, as a cheap mercurial pendulum, one made entirely of glass, the rod and

cylinder being blown in one piece. The height of mercury required in an iron cylinder is stated to be 6·6 ins. The best mercurial pendulums are actually tried and adjusted for compensation at various temperatures, by adding or taking away mercury, as may be required.

The shape of the pendulum-bobs is important. Until lately they were of the form of a double convex lens, this form offering but little resistance in passing through the air, when its edge was always in the plane of motion; but as it was liable to be a little twisted, a varying resistance was offered. This is not the case in the adoption of the form of the cylinder, which is probably the best shape for the bob.

Though there is no such thing in nature as a perfectly isochronous pendulum (one which vibrates different arcs in the same time), and no such thing as a train of wheels with perfectly uniform action, yet pendulums can be kept vibrating, with no greater deviation from isochronism than one beat in half a million.

One of the astronomical clocks (73) has a chronometer escapement, and is constructed to show perpetual day of the month, moon's age, noon and night, day of the week, zodiacal signs, and repeats the hours and quarters.

In the Exhibition are two electro-magnetic striking clocks (27 and 128A); from the pendulum of the latter a number of dials may be worked, the greatest novelty consisting in the method of giving the impulse by means of a *remontoir escapement*, by which the variations of the battery take no effect on the time measured.

Escapements in which the impulse is given to the pendulum by a small separate weight or spring, independently of the force of the train, are called by the French remontoir escapements, because the clock-train winds or lifts up the maintaining force at every beat, or at some given number of beats, of the pendulum. It would be impossible to describe in any reasonable compass the various inventions that have been made for the purpose, both for

clocks and chronometers. For chronometers they have hitherto failed, and there appears to be no doubt they always will, not only on account of the excessive trouble and difficulty of constructing them on so small a scale, but because a chronometer train is so light that there is nothing like the same friction and waste, and therefore variation of force, between the main-spring and the escape-wheel as there is in clocks, especially turret clocks, for which remontoires are most required. But that they can be made and will answer for clocks, both large and small, is fully proved by several which are now at work.

Clocks and Timepieces. (Exhibitors 1, 7, 9, 14, 16, 17, 28, 31, 33, 37, 42, 43, 69, 71, 73, 87, 95A, 96, 99, 100, 102, 103, 104, 106, 109, 117, 119, 121, 122, 127A, 158.)—A clock has been defined to be a machine for counting the vibrations of a pendulum : this is, however, scarcely a correct definition, for it implies that the clock has nothing to do but to count the vibrations, whereas it has also to maintain them, as a pendulum will not continue to swing without some impulsive force applied.

A more correct definition would be, that a clock or watch is a machine consisting of a train of wheels turned by a weight, a spring, or any other nearly constant force, and of which the velocity is regulated by attaching to it a pendulum, balance, or fly-wheel, which always vibrates or revolves nearly in the same time. And the only distinction between a clock and a watch is, that a watch will go in any position, but a clock in one only.

The clocks and timepieces in the Exhibition are too numerous to notice separately ; but among the most novel will be found a hall clock (1) of new design, chiming the quarters and striking the hours on a gong.

A patent clock on the detached dead-beat principle (9). The wheel-work is so arranged, that each vibration of the balance measures half a second, while in the ordinary detached lever it measures a quarter of a second. The teeth of the escape-wheel are not so much undercut as in the

ordinary lever. The pallets from the point of rest are drawn a complete circle to the escape-wheel teeth, so that when the balance returns and unlocks the escapement, there is no recoil. This escapement will carry a heavier balance with less motive power, and consequently requires a stronger balance-spring.

A large or-molu clock (16), representing Jupiter, the twelve Hours of the Sun, Apollo and Diana, and Spring and Autumn strewing flowers and fruit on the earth, is a fine work of art.

A skeleton clock, to go 400 days. (42.)

A clock which goes 32 days: it is designed from Lichfield Cathedral, and strikes the quarters. (43.)

A chime clock, showing simultaneously upon the dial the time in any part of the world. (102.)

A portable spring time-keeper (103), to go 426 days, and a centrifugal or conical pendulum clock (109), said to be capable of performing much heavy work with great accuracy, are among the most curious.

Also, a patent clock (7), the original inventions of which are a new compensation pendulum, and a barometric contrivance to correct, or more properly to prevent, the error arising from the changes in the density of the atmosphere.

The principal weight of the pendulum is composed of glass; and as that substance is less affected by changes of temperature than metal, there is consequently a less error to be corrected by the compensation. The metallic compensation is effected, without any friction, by the ascent and descent of two spring levers with their adjustable weights: the springs would throw the levers upwards, but are prevented doing so by two long and fine steel wires, the length of which governs the positions of the levers. The lengthening of the wires, by heat, allows the springs to raise the balls, and the reverse with cold. There are many self-correcting date-clocks, showing the time of day, &c., day of week, day of month, and name of the month.

The improvements consist in showing the dates through

openings in dial-plates, connected with the above, which are shown thus—Monday, June 30. These alter themselves at midnight, and occur in proper order at all times: thus, if the month consist of 28, 30, 31, or, as in leap year, 29, a continuous movement takes place, which, by carrying forward the dates, brings the first of the next month in due time. A further improvement is introduced in the escapement of these clocks, on the duplex principle, making a full seconds dead beat, thereby reducing the wear or friction. The superiority of these over other date-clocks hitherto in use, consists in—

1st. Nothing more being seen on the dial than is required at one time, all others showing on dials or circles with hands or index points, thereby presenting a mass of writing, figures, &c., not required at any one time.

2nd. The simplicity of the mechanical parts preventing any liability of getting out of order.

A Glass Timepiece. (158.)—Timepiece, apparently consisting of only a dial of glass, on the centre of which an index-hand turns and points correct time, and without any visible mechanism. The dial is of clear glass, and bordered by a rim of brass, supported by an elegant pedestal: this clock strikes the hours and half-hours, and goes twenty-one days.

Arrangements of this kind have been regarded with much curiosity; and several ingenious speculations have appeared as to the mode of producing the movement. Clockwork in the base, moving a toothed wheel round the rim, carrying a magnet, has been suggested as one mode; but when we remember that an index-hand, being nicely balanced, may be moved by the smallest power, we have only to place a watch movement within the axis of the index to effect the regular indication of the hour with the greatest ease.

Geographical Clock. (119.)—It is not easy to render these very ingenious arrangements intelligible without diagrams; but the slightest degree of careful inspection will at once

show the facility with which the correct time at each place, relatively to the one for which the clock is set, may be read. It will not, however, be difficult to understand, that if we paint a map of the world, or of any section of it, upon the face of a clock, and lay down lines of latitude and longitude, it will not be difficult to adjust a moveable band or chain which shall be carried onward by the works from right to left across the dial, with the hours or minutes indicating the time continually on the meridian of every place. Upon this principle this clock is constructed. To a party travelling, this indicator may be rendered a great convenience, inasmuch as, upon the dial-face of a carriage clock, they may have a correct map of the country through which they are passing, as well as a constant indication of the exact time wherever they may have arrived, which necessarily is continually varying with their change of longitude from their point of starting.

Autochronograph. (80.)—The autochronograph is a machine for the instantaneous stamping or printing of time, giving the days of the month, hours, and minutes, night and day. It is employed to register occurrences, individual presence, the commencement and duration of events, &c. As, for example, in railway stations, to note the presence and individuality of guards, engineers, and others, whose absence or substitution might incur danger or inconvenience, and to register the exact time of arrivals, departures, casualties, and incidents.

In public offices, banking and mercantile houses, hospitals, laboratories, dockyards, and manufactories, and in all cases where correct noting of time, or the presence of particular individuals, are necessary for proper arrangement or general safety.

The register, a roll of paper, passes over wheels, bearing the date, hour, &c., in raised figures: a roller drawn across the paper causes the exact time to be embossed upon it. The roller (which is passed in a second) stamps, and at the same time moves the register forward. The paper

may be signed by an individual to prove his presence, and may also be used for remarks, &c.

This machine appears to have many advantages over the ordinary time-tell-tale.

Chronometers. (Exhibitors 1, 3, 7, 10, 13, 19, 21, 32, 34, 35, 40, 49, 52A, 53, 55, 57, 74, 85A.)—The perfection of all the watch escapements is that which has, from its use, acquired the name of the chronometer movement, but was originally called the detached, the balance being entirely detached from everything else except just at the time of action. In other words, there is no dead friction; and, moreover, the impulse is given directly, and nearly at right angles to the line of centres of the balance and 'scape-wheel, as in the duplex escapement, instead of obliquely, as in the vertical, lever, and horizontal escapements, and, therefore, it is not subject to derangement by the variable state of the oil, as it requires none.

The teeth of the 'scape-wheel, instead of resting against a verge, rests against a stop set upon a lever. This lever, having only to move through a very small angle, is set upon a small and stiffish spring, instead of a pivot, which allows it to move just as a pendulum-spring does a pendulum. The other end of the lever has a weaker spring also secured to its inside (that is, the side nearest the 'scape-wheel), and projecting a little beyond its end. On the verge there is a small tooth, or cog, which can pass the spring in the direction towards the 'scape-wheel, by merely pushing it aside, as it has room to bend in that direction; but, in going the other way, the spring cannot bend, and therefore the tooth carries the lever with it, moving on its own spring; and, in so doing, the stop is pushed out of the way of the tooth of the 'scape-wheel, which is therefore let go; and at that moment the long-tooth, or snail-end, attached to the verge (which corresponds exactly to that in the duplex escapement), comes into such a position that the tooth of the 'scape-wheel catches it and gives the impulse. It is evident that this also

is an escapement that requires considerable care in making and using. However, it is never applied to any but chronometers, or the very best watches, and those of considerable size; and persons who possess them are aware that they are instruments of a very different class from an ordinary watch.

If you take a small portable clock, with a balance heavier than any watch-balance, and lay it on its back or side, and observe the vibrations of the balance, you will see that they are much less than when the clock stands up, so that the balance is horizontal. The reason is, that a pivot standing upright, and with its point resting on a hard surface, and merely kept in its place by the hole in which it is placed, both at the top and bottom, moves with much less friction than the same pivot set horizontally in circular pivot-holes. For, however thin the pivot may be made, of course its point can always be made smaller; and, in fact, if the wheel is light, it may approach indefinitely near to a point, in which case there would be no friction—at least, none which the weight of the pivot and its wheel would augment, the lateral friction against the sides of the hole being independent of the weight resting on the vertical pivot. Ship chronometers are, accordingly, kept horizontal by being hung in gimbals, which are, in fact, an universal joint, the chronometer having two pivots, which move in holes in a large ring bearing other pivots, at right angles, which turn in holes in the sides of the box.

Mr. Dent has lately applied the chronometer suspension to compasses; that is, the axis goes right through the card, like the axis or verge of a watch-balance, and rests at the bottom on a jewel, or hard piece of steel, put under the pivot-hole, and at the top, in an ordinary pivot-hole, set in a frame above the card, the whole apparatus, as usual, being swung in gimbals in the same way as the chronometer just now described. There appear, also, to be several collateral advantages in this kind of suspension besides its steadiness; such as the power of making

the compass as sluggish as you please by means of an adjustable spring pressing against the side of the upper pivot, and the power of inverting the compass to ascertain the error of collimation. However, it would be out of place here to dwell at any length on the compass suspension, which is only introduced as an illustration of the principle of suspension of the marine chronometer.

In the escapement of all good watches, and in the best clocks, there are what are called end-stops; that is, the pivots are not kept in their place endways by their shoulders, but by stops of metal in clocks, and jewels in watches, against which the pointed ends of the pivot rest, not of course tightly, but sufficiently close to allow only the necessary shake of freedom. The necessity of this freedom, both endways and sideways, of all the pivots in clock and watch work, is one of the points in which it differs from common engineering; for, in other machines, there is generally force enough to spare, so that a slight degree of tightness in a pivot does not signify, especially if plenty of oil is used. But in the going part of a clock such an occurrence would probably stop it. Besides the end-stops, the pivot-holes for the balance, and the 'scape-wheel, are made in jewels in good watches; and beyond these there appears to be no use in jewelled holes; and watches that are called jewelled in eight or ten holes are often inferior to those which are only jewelled in the four mentioned.

The chronometers, like the clocks, are too numerous to notice separately; but the following have been selected as a few of the most remarkable:—

The Marine Chronometer, with Pneumatic Auxiliary Compensation. (7.)—It is well known that chronometers, on the common construction, have what is termed an "error of extremes;" that is, they will go slow if placed in a freezing or in a tropical region; or, in other words, if they show mean time in these climates, they will gain when placed in a temperate one. The invention to correct this

is to surround the balance with a light cap, which encloses the air in immediate contact with the balance, only when the thermometer is at "temperate." The balance being confined in this space, is retarded in its vibrations, or made to go slower at this temperature. When the temperature either rises or falls, the cap gradually moves away from the balance. The motion of the cap is effected by means of a metallic thermometer, acting as a motive power.

Dent's Chronometers. (55.)—In connection with these, we take the following from the patentee's publications:—"It must, doubtless, be interesting to the public in general, to have the opportunity afforded them of noticing the various statements of reported improvements iu chronometers, that are, from time to time, set forth by their respective inventors. Such accounts, moreover, answer the desirable and double purpose of registering the several ingenious contrivances, as well as of exhibiting in a clear light the nature of the difficulties usually encountered in this important branch of the mechanical arts. It must be confessed, however, that the result of the skill, labour, and expense which have been bestowed within the last 50 years on the improvement of chronometers, affords but little room for congratulation, and must convince every one acquainted with the historical details of the subject, that the road to perfection in the art of chronometer-making is, as in most other arts, a wearisome one, more frequently leading to profitless trouble, than contributing either to the interest of the contriver, or the benefit of the public. Nevertheless, by such investigations has been obtained the knowledge of a curious fact, which has lately excited the attention and ingenuity of various persons engaged in the manufacture of chronometers.

"The fact alluded to is this—that if chronometers, as generally constructed, be regulated to mean time at mean temperature, the chronometer will lose at the extremes of

heat and cold; or, if adjusted to keep mean time at the extremes, they will have a tendency to gain at the intermediate temperatures.

"Another circumstance that tends to aggravate the error arising from the defect of compensation for the diminished tension of the balance-spring at high temperatures, and the excess of compensation for the increased tension at low ones, is, the unfolding or straightening of the circular rim of the balance at reduced temperatures, and the contrary action at high ones. By this action of the rim, the compensating weights are made to describe portions of a spiral curve, whereby the variation in the central distance, due to a given change of temperature, is greater at the low than at the high temperature, which is the reverse of what is required in order to effect the compensation; and although such deviations from the required law of approach of the compensating weights may be rendered less apparent by increasing the weights, yet, in this case, other errors are introduced (which it will be needless here to allude to) that render this mode of proceeding inadmissible, without much limitation. In the construction of the balance I shall here describe, it is not pretended, indeed, that the law of approach is mathematically what it ought to be, in order that the proper ratio may be obtained, at all temperatures, between the tension of the balance-spring and the inertia of the balance; yet, it may be safely affirmed that, in this construction, the variations in the central distance of the weights increase at the higher and diminish at the lower temperatures; which is exactly the reverse of what has hitherto generally taken place in chronometers, and therefore will doubtless afford a much nearer approximation to the truth than heretofore attained. Moreover, the correction for the error alluded to will be a continuous correction; an object of no little importance, and which is not effected in the contrivances lately put forth to remedy the defect by means of supplementary weights, which weights are brought into contact

with the balance rim at a mean temperature. In these contrivances by contact, although chronometers may be adjusted to equal rates at one of the extremes, and also at a mean temperature, yet between these limits, they are obviously subject to an error of the same nature as before, though of one-half the amount only; and in the other half of the range of temperature, when the supplementary weights are brought into contact with the rim of the balance, the law of approach is the reverse of what it ought to be. Besides, the friction at the point of contact is highly objectionable in this mode of correction, and will not only destroy all confidence in the performance of such chronometers at mean temperatures, (the very temperatures at which their services are most required,) but it is also a great violation of the law of continuity, upon the maintenance of which, the correct performance of chronometers must depend."

Mr. Dent then explains the principle of his new patent compensation-balance; but, without diagrams, we could not make this intelligible.

Marine Chronometers. (19.)—There is no particular feature in these chronometers which makes them differ in general appearance from others of the kind; but, by a minute examination of detached parts, more correct proportions will be found than is generally the case.

Marine Chronometers on a new calibre (57), with Arnold and Earnshaw's detached escapement: the compensation balance is of the ordinary kind with Arnold's bar as an auxiliary compensation. The new calibre is based upon the plan of the diameter of the barrel, fusee wheel, and extreme diameter of the balance being the same, namely, $1\frac{5}{10}$ inches: the total weight of the compensation-balance is 5 dwts. Lastly, an original *Eight-day Chronometer* (85A), striking the hours, being a self-acting repeater, and showing the days of the month, is curious as comprising 200 pieces of mechanism in a diameter of not more than two inches.

Watches. (Exhibitors 1, 3, 7, 8, 10, 13, 19, 26, 27, 28, 30, 32, 35, 39, 46A, 52, 55, 57, 71, 78, 81, 86, 94, 124.)—Among these may be named the registered soliclave watch (32): the advantages this unique production is said to possess over the ordinary description of manufacture, are stated in the following particulars:—

1st. A flat and elegant construction, in combination with a height and soundness of movement.

2nd. A perfectly isolated winding apparatus, said to be so managed that the works can sustain no injury from any dust or dirt that may collect about it.

3rd. A key of so simple a make (being but a bar of metal), that while readily procurable under almost any circumstances, is yet so durable as rarely to need renewing.

4th. The facility of winding, the watch not requiring to be opened.

Gold and silver watches are exhibited with patent lever escapement, showing the parts separately (7).

The escapement which is far the most frequent in good English watches is the lever escapement, or, as it used to be called, the detached lever, to distinguish it from another form of it now disused, called the rack lever. If you put a rack or a few teeth of a wheel, of which the pallet armor would be the centre, on the end of the crutch of a clock dead escapement, and let this rack work a pinion set on the verge of a balance, the vibration of the balance would cause the pallets to move as they do under the influence of a pendulum—and this is the rack-lever movement.

It is, however, liable to stop if the balance is accidentally stopped at the neutral position, on account of the friction between the rack and the pinion; and, morever, the lever, or crutch, and pallets, are carried farther the farther the balance vibrated. This cannot be helped with a pendulum, on account of the small angle which it moves through; but it can with a balance, since that moves through such a large angle, that the arc described by a pin set a little distance from the verge will cut the arc

described by the end of the lever, so as to include a very sensible depth between them. Consequently, if the end of the lever merely has a nick in it, and the verge, instead of being a complete pinion, has one tooth or pin that will fit into the nick, the lever and pin will act together as a wheel, and for a short distance in the middle of the vibration, but as soon as the pin has got out of the nick, the balance may turn as far as it pleases without moving or being even in contact with the lever; and when it returns, the pin will go into the nick again, and first move the dead part of the pallet off the tooth of the scape-wheel, and then receive the impulse and leave the opposite pallet with a tooth resting upon its dead part. Therefore this was called the detached lever, as the lever is detached from the balance, except during the middle of the vibration. The pin is usually made of a jewel, and it works with so little friction that you can hardly (if at all) stop the watch, any more than a clock with a dead escapement when the pendulum is taken off. The pallets are also always made of jewels in good watches. The practical advantages of this movement are, that it is not only a very good one, being like the dead escapement of a clock, and without the dead friction, which is very nearly removed by the detachment of the balance from the pallets, but it is, moreover, easy to make and safe to wear; and if the watch gets such a fall as to break the verge, which is always the first thing to break, it can be mended for a few shillings—the verge in this escapement being nothing more than a plain arbor, which carries the pin set upon a small collar; whereas, in other escapements, the verge itself is comparatively complicated, and expensive to make and mend.

The lever watch (10), to show dead seconds on the one train only, with the usual number of vibrations or beats, is ingenious; and the gold and silver watches, with compensation balance, may be regarded as excellent examples of English watchmaking.

The balance of a watch requires compensation much more than a pendulum, if it is to be exposed to such changes of temperature as chronometers are, though watches carried in the pocket are not subject to much variation of that kind, unless they are left exposed in cold nights. The variation in the elasticity of the spring, which effects in a small degree the vibration of a heavy pendulum whose time is mainly determined by gravity, affects a light balance, whose time of vibration is mainly determined by the force of the spring a great deal more.

The difference in the amount of compensation required by a balance and a pendulum is so great that it cannot be effected exactly in the same manner, though all the methods that have been invented depend upon the same principle, of making small weights attached to the balance approach nearer to the centre as the heat increases, so as to diminish the moment of inertia or the resistance to the force of the spring.

Among the watches will be also seen a watch keeping correct time (81), though suspended in a glass globe filled with water. The object of the invention is to secure the protection of time-keeping and other instruments from water, sea-damp, &c. A sporting-watch (86) which shows the time to one-sixth of a second. German silver watches, plated with silver (94); and specimens illustrative of the progressive stages of manufacture of a lever watch. In addition to these are many examples of extremely minute manufacture, which are certainly triumphs of skill and industry.

Globes and Orreries. (Exhibitors 175, 188, 198, 200, 207, 212, 218, 354.)

Newtonian Globes. (212.)—These globes are hung in stationary rings or meridians, and are capable of turning upon their axes or poles, for the purpose of showing the real diurnal motion of the earth, and the appparent diurnal motion of the heavens, according to the Newtonian system or real structure of the universe. Each globe is

mounted on a single pedestal—avoiding the necessity of a cumbrous and objectionable frame and wooden horizon; and in place of the latter a sliding annular plate is substituted.

On the terrestrial globe, this plate acts as a terminator to indicate the line of demarcation between day and night spread over the earth's surface, and shows, at any given time, what parts of the earth are illuminated by the sun, enjoying the light of day, and what parts are in shadow, experiencing the darkness of night.

Upon the celestial globe a similar sliding annular plate is made to represent the visible horizon of any place on the earth's surface; and to show what part of the heavens would be there seen at a given time—together with the rising and setting of the sun and moon at different seasons and periods of the year.

The terrestrial globe represents in miniature the spherical form of the earth; upon the surface of which are depicted the several continents and islands, oceans, seas, and rivers, all in their true relative positions, shapes, and comparative extents.

As in nature the earth revolves upon its axis (which is an imaginary line through its centre), so the terrestrial globe is made to turn upon pivots, called its north and south poles, in a fixed ring, called the meridian—because, when any place upon the earth's surface passes under it, the sun's rays fall more directly upon that place than at any other time; and it is then meridian or noonday there. A great circle is marked round the globe, midway between the poles, called the equator—because it divides the earth into two equal parts, viz., the northern and southern hemispheres.

A small brass ball, representing the sun, is made to slide upon the meridian of the globe, for the purpose of being readily adjusted to the declination or perpendicular position of the sun north or south of the equator, according as the sun's declination varies from day to day throughout the

year, and causes the change of seasons. The globe is so mounted upon its pedestal, that the axis always lies in its true inclined position, and points to the north polar star in the heavens.

The declination of the sun for every day in the year is shown by an analemma or scale, drawn upon the globe; and, by sliding the brass ball upon the meridian over the points of declination indicated by the analemma, the sun's vertical position over the earth for any given day will be perceived.

At the greatest declination of the sun (distance from the equator), north in our summer and south in our winter, imaginary circles are drawn round the terrestrial globe, called the tropics. These circles are imaginary lines generated upon the earth by the vertical sun at the periods of the summer and winter solstice.

The circle north of the equator is called the tropic of Cancer; because the sun, when entering the sign Cancer in the heavens, traces this imaginary line upon the earth; the southern circle is called the tropic of Capricornus, because the sun traces that imaginary line on entering the sign Capricornus: the space or band, stretching round the earth between these tropics, is called the torrid zone, in consequence of the intense heat of those parts of the earth over which the sun is vertical twice in the year.

Connected to the brass ball, representing the sun, there is, supported by an arched arm, an annular plate, called the terminator; because this annular plate, embracing the middle of the globe at an equal distance from the brass ball all round, marks the line at which daylight terminates and night begins, on every part of the earth's surface. The portion of the globe above the terminator, towards the sun, represents that half of the earth's surface which is illuminated and experiencing the light of day; and that below the terminator is the half of the earth's surface which is in shade and enveloped in darkness, called night.

The artificial celestial globe represents the imaginary

sphere of the heavens, and if made of glass, or other transparent material, the stars so placed within it would be seen through the glass on the outer surface of the sphere, in their relative positions, and of the several magnitudes shown;—such a delineation of the starry heavens is the artificial celestial globe which we are about to consider.

For the convenience of readily ascertaining the situation of any appearance in the heavens, the ancients (probably the Chaldees) thought it desirable to give names to certain remarkable groups of stars, which they called constellations, and they appropriated to each group figure, as a man or a beast, to which some poetic or historical interest was attached:—thus we have the groups of stars called Aries the Ram, Taurus the Bull, Gemini the Twins, the Great and Little Bears (Ursa Major and Minor), the Æthiopian king Cepheus and his queen Cassiopeia, with their daughter Andromeda, and the hero Perseus, Orion the Hunter, Auriga the Charioteer, &c.

Having thus imagined constellations, it was easy to describe the situation of any star or other appearance in the heavens, by saying it would be seen near the Ram's horn,—the Bull's eye,—in the tail of the Great Bear,—upon the sword, belt, helmet, or foot of Orion,—or between the shoulders of Auriga, &c.

The principal stars visible in the apparent concave or heaven were thus grouped into constellations, the most important of which, twelve in number, had symbolic figures appropriated to them, and were called the signs of the zodiac, because they extended round the heavens, and occupied a space or zone called the zodiac, in which the sun, moon, and planets, appeared to perform their respective annular courses. Through the middle of this zodiac, an imaginary line is delineated, circumscribing the celestial globe, called the ecliptic, in which line the sun seems to travel in its annual circuit, and, by the graduation of which, celestial longitude is reckoned.

The celestial globe, in order to represent the apparent

diurnal motion of the heavens from east to west, is made capable of revolving on its axis, by pivots, turning in a meridian, fixed on a pedestal, in the same manner as the terrestrial globe. These pivots, called the celestial poles, represent those imaginary points on which the celestial sphere appears to rotate daily: they are situate in the heavens, perpendicularly over the north and south poles of the earth,—the extremities of the imaginary axis whereon, as before said, the earth really turns from west to east.

A great circle round this globe, forming an acute angle with the ecliptic, is delineated at equal distances from the poles, called the equinoctial line; because, at the seasons of spring and autumn, when the sun appears to be crossing that line, there is an equality of day and night (twelve hours of each) on all parts of the earth. This circle in the heavens is immediately over and coincident with the equator on the earth, and is, in like manner, divided into 360°, by which right ascension is measured; that is, the comparative distance of any star or other celestial object, reckoning eastward from a certain point in the heavens, called the vernal equinox (the first point of the sign Aries). The right ascension of any object in the heavens is also reckoned in hours and minutes, agreeable to the apparent rotation of the sphere in twenty-four hours. There are also two other great circles drawn on the celestial globe, at right angles to the equinoctial line, and passing through the poles. One of these great circles is called the equinoctial colure, because it intersects the equinoctial points of the ecliptic at the beginning of the signs Aries and Libra (the periods of the equinoxes, spring and autumn); and by the graduations on which line declination is measured, or the distance of the sun, a star, or other object in the heavens, north or south from the equator.

The other great circle is called the solstitial colure, because it intersects the ecliptic line at the solstitial points (the beginning of the signs Cancer and Capri-

cornus), where the sun is seen in the highest and lowest parts of its apparent path through the heavens at the seasons of summer and winter. By this line celestial latitude is measured, or the apparent distance of the sun, a star, or other object north or south from the ecliptic.

In performing problems on these improved Newtonian globes, relative to the phenomena of the heavenly bodies, it is intended that each phenomenon shall be shown in the way it really occurs in nature, as demonstrated by the Newtonian system, which is not always the case in performing problems by globes in the old modes of mounting.

The Slate Globes (212) have the latitudinal and longitudinal lines marked on them, and are intended for the use of students who have attained a certain proficiency, to draw the countries on in their true position from memory.

A Terrestrial Globe (198), 30 inches in diameter, shows —1st. The geological structure of the earth; 2nd. The currents of the air, trade-winds, monsoons, &c.; 3rd. Currents of the ocean, and trade-winds; 4th. Isothermal lines, or lines of equal temperature. The stand is handsomely carved in walnut. It has, at the four corners of the base, heads emblematical of the four seasons. Surrounding the compass-box are sitting figures, representing the four quarters of the globe, with their appropriate emblems, and the circular supports of the horizon are composed of clusters of fruit indigenous to the quarters over which they are suspended.

Terrestrial and Celestial Globe combined. (218.)—This exhibitor has certain ideas connected with the geometric laws regulating the form of the sphere, which can only be understood by reference to his work, "The Harmony of the Universe," to which the reader is referred.

He exhibits a globe of 25 inches in diameter, with the terrestrial and celestial mass superimposed one on the other, and with a new management of the horizon and zodaic to show by the latter the planetary motions. The

celestial map being superimposed on the terrestrial sphere, the globe itself becomes the best catalogue of the stars, as the principal stars are immediately seen superposed on localities of the earth, the names of which may be given to the stars themselves: this plan gives some facility to the calculations of longitude and latitude.

Another globe is of papier maché divided in "*harmonic*" pieces, so as to be rebuilt or kept in a small box at pleasure, or the pieces can be arranged on brackets for ornaments for drawing-rooms, cabins, &c. This is accompanied by a skeleton globe, to show how to divide and rebuild the globe on the frame.

Beyond these there is exhibited a small machine, said to be constructed with great accuracy, consisting of a sphere of ivory divided by the "harmo-spherion" quadrangular system, enclosed in horizontal and vertical circles: the object of this is to demonstrate the dimensions of all the lines of the "harmo-spherion," for which the poles of the ivory sphere can be varied by means of two sets of screws into any of the intersections of its circles. There is also another sphere of ivory divided by the "harmo-spherion" pentagonal, which can be applied for the same purpose. This machine is said to mechanically satisfy a problem which, for thousands of years, mathematicians have attempted to solve without success, and which has ever been considered as incapable of solution!

The Periphan. (354.)—This is the name given to an instrument, by which the ordinary solar and lunar phenomena are elucidated in a clear and simple manner. It consists of a terrestrial globe placed in the centre of a series of rings, on which are again mounted the sun and moon, which slide freely on the wires.

To adjust the instrument for any particular place and day, we first fix the circular wire (called the horizon-wire) in such a position (according to the degree marked on the vertical circle), that it might describe the horizon of the place; we then turn a large thumb-screw till the outward

semicircular wire (called the solar-wire) is just opposite to the day as marked on the horizontal ring, and move the red orb (representing the sun) up or down till it is as near as possible to the day; we then, by means of the thumb-screw, turn the solar-wire till the centre of the sun is in the plane of the horizon on the east side, and the index will show the time of sunrise: and, if brought to the west side, it will show the time of sunset. The small white orb represents the moon.

The causes of the harvest-moon, of eclipses, of the difference between true and apparent time, and many other subjects connected with astronomy, are by this instrument rendered remarkably perspicuous.

Two small appendages accompany it: one for measuring the sun's altitude, &c.; the other for describing the apparent diurnal motion of the ecliptic, and for showing the angle which, at any particular time, it makes with the horizon.

The Portable Globes (234) are manufactured of strong tissue paper, so that they can be folded into a very small compass, and very readily inflated when required.

Kites and Kite Carriage. (234.)—These kites are made of stout calico, having joints in the standard and wings, so that the kite, six feet in height when extended, may be carried as a fishing rod when closed. They are constructed so truly that there is no wavering in their flight, and they are very durable.

The Charvolant, or *Kite Carriage*, is a car drawn by kites. The exhibitor gives the following statement of the power of his kites for this purpose:—

The power of a kite 12 feet high, with a wind blowing at the rate of 20 miles in an hour, is as much as a man of moderate strength can stand against. With a rather boisterous wind, such a kite has been known to break a line capable of suspending a weight of 200 lbs. This kite spreads a surface of 49 square feet. It should be particularly noticed, that these may serve as standing ratios, from

which, by the Rule of Proportion, the power of larger kites can be calculated. Two kites, one 15 feet in length, and the other 12 feet, have sufficient power to draw a carriage with four or five persons when the wind is brisk.

Orreries, &c. (Exhibitors 195, 212, 215.)—Orreries are instruments whereby the various phenomena connected with the planetary system may be explained to students in a more clear and easy manner than by verbal description, even if assisted by numerous diagrams. In these instruments the real motions of the heavenly bodies are shown by means of toothed gearing, actuated either by hand or by clockwork. Owing to the complicated wheel-work required to communicate the proper motions to the earth, moon, and planets, orreries have hitherto been expensive instruments to construct, and consequently their high price prevented them from being made use of to any considerable extent for educational purposes. In order to obviate this objection, the Exhibitors (212) have devised an improved school orrery, and greatly simplified the plan of constructing orreries for schools. In these the complicated wheel-work is dispensed with, and the requisite motions to illustrate the principal celestial phenomena are produced by means of plain wheels and bands, so that an orrery or planetarium suitable for all ordinary purposes may now be produced at little more than one-third the usual cost of these instruments.

The Great Vertical Orrery. (195).—It is nine feet in diameter, and is designed to aid in the study of astronomy, representing the principle bodies in the solar system; and shows all the planets and their attendant satellites revolving round the sun in their proper order. This orrery gives a general idea of the relative position and revolutions of the planets and satellites.

The rate of motion on the orrery is for Mercury 1 minute, the Earth 4 minutes, Saturn 2 hours, and for Neptune nearly 11 hours.

A Lunarian (191), the merits of which are, that the

instrument has a contrivance for exhibiting the diurnal phases of the moon as it revolves round the earth; and also for describing the ascending or descending nodes, thus showing the cause and nature of an eclipse.

Mechanical Indicator (208), for teaching geography. This map is on a board. The degrees of latitude and longitude are shown on its face; but instead of the names of countries being painted on it, a number of brass pegs are placed where they should have been. The pupil is required to point to a certain place. He touches a peg, and a corresponding one rises with the name, showing whether or not he has touched the right one.

The Astrorama (193) is in form a silk umbrella, perforated in such a manner as to represent the stars of all the northern constellations, and of the most important of the southern. The figures of the constellations themselves are also depicted and named on the concave side of the instrument. The little book by which it is accompanied furnishes instructions for its use, and by means of the two, most of the problems, &c., usually performed on the celestial globe, may be worked in a simple, intelligible, and amusing way, without the impediments to the understanding of the young pupil, which the convex surface of a sphere, and the equally unnatural form of the planisphere, necessarily produce.

The Geographical Instructor (188) is a globe which is continually revolving east with an endless rotary motion and a vibratory action; it makes one revolution in every hour, and in 24 hours it shows the two seasons of the year—winter and summer, the sun being so fixed as to show its effect on the north and south poles, and its appearance on the earth every month in the year. The interior arrangements of this globe are so constructed as to show the return of the seasons, and the exact motion of the earth in its varied rotary action. The observer will perceive, by the scarcely visible motion, when the seasons are beginning to advance or recede from the north or south poles. The

exterior propelling power which forms the time-table and rotary action, may be detached from the crank-handle motion, that the globe may be propelled by the crank, for the more ready teaching the use of the globes, and for other scientific purposes.

The Orthochronograph. (347).—An instrument for ascertaining correct time—for country clergymen, watchmakers, and persons who have the care of public clocks, the lover of mechanics, or the mathematician, while the mariner will find it serviceable when, on making the land, he wishes to test the accuracy of his chronometer.

The instrument consists of two horizontal circular plates parallel to each other; the upper one has an aperture for the passage of the solar ray, the lower one is engraved for the purpose of making an observation. The lower plate is supported by a pillar resting on a tripod foot, furnished with three adjusting screws. The upper plate is raised or lowered by a rack working out of the pillar, by means of a pinion and friction roller acted upon by a milled head.

The method of taking an observation is to place the instrument upon a stand, taking care that the letters N. and S. on the lower plate be placed north and south, or as nearly so as possible. If this be determined by the compass, allowance must be made for the variation; but rigid accuracy is not essential, as there is sufficient range on the lines for a long interval. By means of the three screws or feet, adjust the instrument to a horizontal position, which is proved by placing the spirit-level upon the lower plate, first east, west, and afterwards north, south. Then raise or lower the ray-plate until the sun's ray appears on the line on which it is intended to make the observation. The most simple process is by two observations, either when the ray is in contact with the outer side of the belt, or appears exactly between the double lines.

In either case note the hour, minute, and second, when the ray is in its first position, leave the instrument stationary until the ray, after traversing the plate, has arrived

at the second position, and again note the time as accurately as possible; add the results thus obtained together, and divide the sum by two. The latitude of the place of observation being known, or observed from the table of latitudes, turn to the table of equal altitudes, and find the equation for the day of the month, which is to be added or subtracted from according to the direction there given; then the difference between this result and 12 hours will show the error of the clock as compared with solar time. Lastly, this error is to be corrected by the equation of time. When the error and the equation are both fast or both slow, subtract the one from the other—when they differ, add them; then the sums or difference will give the error as compared with true mean time.

Models and Maps of the Moon. (Exhibitors 677, 688, 372.) —Mr. Nasmyth's researches are well known. By the aid of telescopes constructed by himself on the most approved principles, he has devoted years to the examination of the lunar surface. The map exhibited is one of the results of his observations: on it are shown the relative positions and characters of the most striking features of its surface, as they appear when seen under the most favourable circumstances in respect to light and shade.

The model (677) is intended to illustrate the discoveries of astronomers with respect to the physical peculiarities displayed on the visible surface of our beautiful satellite, with the view to render those wonders appreciable by young students in the commencement of their scientific inquiries; thus attempting to convey to the mind, at one view, the three grand distinctive features of this body; giving a general idea of their relative position; and showing that this surface is either thrown up into circular ridges, conical hills, and mountain chains; depressed into valleys and cavities, or spread out into slightly undulating plains of vast extent.

It is also designed to draw the attention of the young geologist to the distinction subsisting between the nature

of the shadowed and the more brilliant localities of our secondary: and, finally, to elicit the more lengthened opinions of the man of science, as to the probable stage at which the planet may have arrived, admitting it to be in a transition state. Mr. Nasmyth conceives the moon's surface to indicate perfect repose; no change, in all probability, has taken place for ages.

This model is an original production of a lady, who appears to have studied with much zeal all that has been published relative to the condition of the lunar surface.

Model or Relief Mapping.—The advantages of the model map (317) are, its being intelligible to all persons, at the same time that the utmost accuracy is preserved; its admitting of geological record without defacing the surface or confusing the observer; its admitting of considerable embellishment as a work of art without depreciating its use as a documentary record; and its presenting to the eye all the capabilities of an undulatory surface, not only for effective and systematic drainage with respect to outfalls, but for the profitable distribution and application of the water and refuse collected by draining, in a form so simple and natural that landowners and others, without qualifying themselves as engineers, may scheme and calculate the value and use of surplus waters. It is particularly in respect of this last point of view that attention is sought to the advantage of modelling. It is not necessary to say, that from the wet land of this country—land already drained, or to be drained—a vast quantity of water is derivable; the existing desire among landowners and occupiers to drain their lands and to get rid of the injurious waters, testifies to this fact: but it is not so generally admitted, that these injurious waters, rendering so many acres comparatively unproductive, are, by a simple consideration of the altitude of adjoining lands, frequently available for profitable use: still such is the case. The greater portion of the wet land of this country, and in Scotland and Ireland, will be found, on examination, to be situated

on higher levels, and it will be found also that lands susceptible of irrigation lie below them; so that by directing the main drains to a particular point of an estate, the water thus brought together may be used in irrigating, or turned to profit, down a steep inclination, as a motive power.

Angle Meter. (374).—This instrument is so constructed that all angles of rocks, or strata, can be taken by it with the greatest accuracy; thus enabling the miner more readily to sink shafts, or drive levels, to work mines, or to discover mineral lodes. It is also calculated for taking angles or inclinations in engineering and architecture, road and drain making, levelling, or elevating guns and field pieces, &c. &c.

Level for the purposes of Draining. (374.) This level is formed of an oaken rectangular rod, turning upon an axis placed at the middle of its lower surface, and by means of a plate and screw secured firmly at a horizontal level, or any given inclination. On its upper surface, immediately above the centre of motion, is placed a small spirit-level, and at each end of the rod an upright plate of brass, containing the cross-wires. At the end nearest to the observer is placed an additional sight, moveable by means of a screw within a graduated groove, which indicates by the value of its divisions not only the line of horizontal level, but the rise and fall of distant objects above or below the place of observation.

The levels (320) are of a superior description, and should be examined.

Draining Levels, &c. (Exhibitors 317, 353, 362, 374.)—The object of the instrument (317) is to assist foremen and workmen in testing and preserving a uniform fall in all works requiring such regularity. A spirit-level, if understood by workmen, is a thing easily put out of order, and is at all times liable to be broken; its use, therefore, is dreaded by workmen, as a process involving too much time, care, and precision, for their fingers to perform.

If the first object of the drainer is to direct his drains

according to the best fall of the ground, the next point of importance is, that the floor of the trench, and the course of the pipes or conduit, should be even and regular from the top to the bottom of the drain, so that the contents may flow easily to the outlet. Any hollow in the drain intercepts the sedimentary matter which the flow of the drain-water would otherwise carry out with it; the sectional area of the water-way is thereby lessened, and the sediment, gradually accumulating, after a time causes a stoppage, the drain bursts, and the work has to be re-done.

In land drainage and towns sewerage the great desideratum is how to connect with the ground plan of any district the altitudes of its surface in *every part*, so as to convey practical data for the execution of the necessary works. It is true that, apart from each other, an accurate ground plan with longitudinal and cross sections, or a system of contours, may be taken and so represented on paper that any one of ordinary capacity may understand them in their individual characters; but there are few persons not practised in such matters who can connect a ground plan with either detached sections or connected contour lines with sufficient mental facility for useful application.

Drawing and Mapping Instruments. (Exhibitors 318, 323, 340, 347, 348, 361, 352, 353, 356, 361.)—These instruments are very numerous, and without entering fully into a description of them, little more can be done than refer to them from the numbers in the Catalogue.

(318.) The object of this instrument is to draw volutes and other spiral curves, which it effects in a very perfect manner, and with much novelty in its arrangements.

(323.) Those instruments are shown by the exhibitor for the superiority of the workmanship, which consists in the joints and points being made of the finest-tempered steel, and all the fittings and setting being true, so that no shake or tremor may occur when in use, which enables the engineer, surveyor, or student to set out the most delicate and minute plans with accuracy and despatch.

(352.) For drawing radiating lines, and (348), the *metrograph*, an instrument to enable a person to draw any object from nature, by actual measurement, should be examined.

The case of drawing instruments (322), is one of the largest and most complete of its kind.

Azimuth and Steering Compass. (55).—Amongst the evils arising from the present construction of compasses are, the friction arising from the imperfect modes of suspension, which is that of a hollow cup in the centre of the needle, resting upon a steel point, in which case it is obvious that a want of horizontality in the card will cause considerable friction between the convex sides of the pivot and the sides of the cup. Secondly, a considerable error is caused by the assumption, that the *magnetic axis* of the needle coincides with what is called the *maker's axis*, which is the line determined by the marks or zero points on the extremities of the needle; which error in flat needles, such as are usually applied to compass-cards, is frequently of such magnitude as to be quite inadmissible, even in compasses for common purposes, much less for those intended for accurate experiment. Thirdly, another source of inconvenience and inaccuracy arises from the unequal amount of inertia as regards the axis, or horizontal line drawn through the centre of the card, about which line it is compelled to vibrate or deviate from its horizontal position by means of the alternate pitching and rolling of the vessel. To explain this, suppose a vessel steering N. or S. by compass, a pitching motion would in this case cause the card to move about a line drawn through the E. and W. points, and this arises from the circumstance of the gymbal apparatus in which the card is suspended not completing its vibration in the same time as the card does in its vibrations above and below the horizontal plane; which difference in the time of vibration of each, causes the convex sides of the pin upon which the card turns to come in contact with the sides of the cup in which it

moves, and thereby communicates a vibratory motion to the card. From the position of the needle with respect to the axis referred to, it is plain that the distance of the centre of gyration, and consequently the time of vibration about that axis, is a maximum.

Again, in a rolling motion (that is, about the axis of the vessel), the vessel's head being in the same direction, the card from the same cause will in this case vibrate about an axis drawn through the N. and S. points of the card; and the time of its vibration is then a minimum.

In any other motion of the vessel, the corresponding motion of the card is compounded of these two effects, which produces the "waddling" or undulatory motion observed when the motion of the vessel is considerable and irregular. However well, therefore, the gymbal apparatus, in which the card is placed, is balanced, yet as the card has a motion or time of vibration peculiar to itself, depending upon the position of the axis of its vertical vibrations with respect to the axis of the needle—which vibrations are not altogether under the control of the gymbals, although its vibrations are continually checked, and its quiescence, disturbed by it, in consequence of the supporting pin coming in contact with the sides of the cup, as before mentioned—yet in the present construction of the binnacle compass, the card ever will be subject to irregular deviations from the horizontal plane, arising from this cause.

The mode by which these evils have been removed is, by altering the nature of the suspension; that is, by suspending the card in a similar way to the balance of a chronometer, and with equal delicacy, both ends of the pivot acting on diamonds, and the holes jewelled, by which means the card is constrained to move very nearly in the horizontal plane, since in this respect it is entirely under the control of the gymbals. The friction is also considerably reduced by this mode of suspension. The great accuracy with which the card returns to the same

position has been shown by a great number of experiments.

The Altitude and Azimuth Circle (322) is the only large instrument in the Building with divided circles: it reads to seconds, and is in many respects to be regarded as an excellent example of the work of a mathematical instrument maker.

Sextants are exhibited by 271, 332, 349, 350, 351; and numerous surveying instruments of great value and most excellent character will be found in this Class. The compensation bars and microscopes, used in the triangulation of the United Kingdom, are deserving of particular attention, from the perfection of workmanship and completeness of all the adjustments.

Astronomical Instruments. (Exhibitors 187, 254, 320.)—In addition to the few instruments of this Class in the Gallery and Ross's large equatorial telescope, Messrs. Troughton and Simms have recently placed near the West Avenue a collection of first-rate astronomical instruments. The largest of these is a six-feet equatorial for latitude 25°, with clock movement, regulated by a centrifugal governor. The celebrated Westbury circle, by the late E. Troughton, is an instrument of much historical interest. A four-foot transit circle is a highly-finished instrument of the best construction. The lamp that illuminates the cross wires is made available for illuminating two micrometer microcopes, by the aid of two prismatic lenses: the pencils of light pass through two apertures in the sides of the lamp. A transit instrument, made for the coast survey in the United States, is a very well-arranged instrument; the axis is converted into a telescope by means of a small object-glass at one end and an eye-piece at the other, and the instrument itself is capable of being raised on Y's of vulcanised India-rubber, and turned round the prime vertical by a wheel and pinion, for determining the east and west points, pivot errors, &c. A two-foot altazimuth, with nadir point, is a very fine instrument; a small equatorial, a small diagonal transit, a transit theodolite, and a mounted

reflecting circle and sextant, complete this splendid series of instruments. There are, also, some standard measuring rods. One of these is supported on mercury, as proposed by Mr. Sheepshanks; another by a series of equal-armed levers, as proposed by Professor Miller.

Near these are a few highly-finished instruments by Dollond. A small double transit circle appears to be a very complicated instrument. We also observe a two-foot transit circle, divided on both sides, with four micrometer reading microscopes, the supports of which look rather weak. There is also a telescope which we suppose to be a comet-finder, and two small transits.

Tide Gauge (152).—Several contrivances have been introduced from time to time for registering the rise and fall of the tide. These have been more or less accurate, arising from the friction and defects in the indicating adjustment. The distinguishing peculiarity of the tide-gauge exhibited is its freedom from grip or friction. One is stated to have been working for three years, and the curves of the rise and fall of the tides, day and night, for the whole of that time have been traced faithfully and clearly. Time is noted by an astronomical clock, which keeps mean time, and is made to go more than fourteen days without winding up; so that the instrument, which is perfectly self-acting, and requires no superintending, can be left to itself for the full period of fourteen days, that is, from new to full moon, and full to new again, or, in other words, from one spring tide to another. Then the diagram, on which has been traced the tidal curves for fourteen days, is removed and another put on, and then—and only then—the clock requires rewinding, thus insuring the necessary attention at the proper time. A system of wheel-work is applied externally to show the depth of water on a large scale; and *externally*, to an observer at a great distance, the actual depth of water there may be on bars, or shoals, or any other given place, at the moment of observation.

The large wheels are turned to a certain circumference;

and this machinery is entirely worked by the tide-gauge, and at any distance from or elevation above it.

An Apparatus of peculiar construction, showing the Rise and Fall of Tides. (190.)—This must be classed among one of those curiosities of the Exhibition which it would have been friendly to have excluded. There is little doubt but the exhibitor is a man of an ingenious mind and much industry, but unfortunately he represents a class of men who venture to invent while yet in perfect ignorance of the truths which investigation has placed beyond all doubt. This is mentioned in no unfriendly feeling, but the contrary; and as an example, the exhibitor's own words, without further comment, are left to speak for themselves:—

"The article I sent to the Exhibition is an apparatus to illustrate the idea of the earth being a living creature encased in a shell, as a snail-house or sea-shell, and by the action of its heart causing the tide to ebb and flow.

"Press down the blower, and the heart (as seen through the glass that is on the top of the shell) will contract, causing the tide to rise; let the air out of the shell, and the heart will expand, causing the tide to fall.

"I want a patron that would enable me to show how the tide causes the rotary motion of the earth, which only poverty prevents my doing."

Metal Gauge (298) for ascertaining the thicknesses and weights of plates and rods of metal.

The principle of this gauge is the progressive movement of a most accurately cut screw, to which is affixed a dial or circular index: this can be divided, so that each space shall indicate that the screw has advanced the 1000th part of an inch, or otherwise set out as may be required. Thus, to show the weights per foot super, run, &c., of any particular metals, alloys, or other material, or with any arbitrary line of numbers, such as the ordinary wire gauge.

The gauge which is placed in the Great Exhibition has

the outer circle of the dial divided, so that each minor division represents 1 oz. per foot superficial of sheet iron, sp. gr. 7·68. the pounds and quarters being marked off up to 20 lbs. to the foot, which is exactly half an inch thick. The weights of any other metal, &c., in like manner may be engraved on the dial, or of several metals in concentric lines; or, the dial only being divided to show the weight of one, all others may be ascertained by the use of Hayward's sliding scale of equivalents.

This scale of equivalents appears to have been calculated with much care, and if found to be, in practice, strictly accurate, it must prove very valuable.

Thread Counter (265.)—This instrument, called a linen-prover, is for ascertaining the number of threads, warps, or shutes in any textile fabric, especially adapted to the use of manufacturers of lawn, linen, cotton, and silk goods, and also useful to merchants or dealers in these articles, to ascertain the quality of their goods. Without a drawing this may not be clearly understood. Under an eye-glass is a fine pointer, which is moved from thread to thread over a scale, by means of a very fine screw, so that the numbers are accurately measured off in a very easy manner.

The Opisometer.—This simple instrument measures the length of roads, rivers, fences, walls, &c., on any map or plan which is drawn to a scale, without requiring any arithmetical calculation. It may also be applied to measure any curvilinear surface.

The principle of the opisometer is, that, after having been applied to any line, it retraces or measures backwards precisely the same length on the scale with which the line is to be compared. It consists of a milled wheel with a steel screw for its axis, mounted on a convenient handle; the circumference of the wheel being accurately determined, an index is attached, which moves over one graduation at each revolution of the wheel. To measure the length of a line, as the distance between two towns by the

road traced upon a map, turn the milled wheel up to one end of the screw until it stops, and place the instrument on the map in an upright position, as represented in the drawing, the wheel resting upon one extremity of the line to be measured, then run the wheel along the road, following every bend as closely as possible. Care must be taken to keep the wheel in contact with the paper, but the pressure need not be such as to injure the map. When the wheel has arrived at the other extremity of the line, lift the instrument carefully from the paper, and carry it to the zero end of the scale, run the wheel backwards along the scale until it stops at the same end of the screw from which the measurement began; the division of the scale at which the wheel stops shows the length of the line measured on the map. Should the scale be shorter than the line measured, when the wheel arrives at the end, carry it to the zero mark again as often as may be necessary, counting the number of repetitions.

The difficulty of measuring lines of double curvature is entirely removed by the use of the opisometer.

The Tempest Prognosticator (151.)—Dr. Merryweather, having paid much attention to the peculiar habits of the leech, and particularly noticed the influence of electric changes upon that creature, was led to the construction of the instrument exhibited. Leeches leave the water and crawl to the upper part of any vessel in which they may be kept, under certain conditions connected with atmospheric changes, and these the exhibitor is disposed to connect with storms. He states, in his 'Tempest Prognosticator,' that he has satisfactorily predicted a great number of severe gales by taking the leech as his indicator. In the arrangement exhibited there are some neat mechanical contrivances, by means of which, as the leech crawls up out of the water, a bell is rung, which is the indication of atmospherical change.

The Centrifugal Machine, for illustrating Planetary Motion. (187.)—The chief object of this machine is, to exhibit the

remarkable centrifugal tendency of all bodies, having a longer and shorter axis, to revolve upon the shorter. This tendency is common to all planetary bodies, as far as we are acquainted with their motions, as well as to all bodies on or near the earth's surface. To illustrate this, a model of the planet Saturn is suspended by a string, attached to its *longer* axis, and set in revolution by means of clock-work. As soon as it is in motion, the model of its own accord quits the vertical position, and assumes a horizontal one, which it retains as long as the motion is kept up. It is thus seen to rotate on its *shorter* axis in a space representing the solar system, surrounded by the twelve signs of the zodiac, in the same way as the planet itself is revolving at hundreds of millions of miles distant.

Lenses. (Exhibitors 250, 254, 259, 278, 289.)—The process of grinding lenses is one of very great nicety.

The glasses for the lenses having been selected of suitable quality, they are brought to the circular form with flat pliers called shanks, the jaws of which are made of soft iron, that they may the more readily embed themselves upon the glass, and take a firm hold. The pressure of the pliers, applied near the edge of the glass, causes it to crumble away in small fragments, and the process is called shanking or nibbling.

They are next coated on one side with a layer of cement, about half an inch thick, to form a handle, by pouring as much melted cement as will lie on the glass without running off from a ladle in small quantities.

The glasses are in all cases rough ground separately, either with river sand and water, or coarse emery and water, until the surfaces are brought nearly to the curve of the shell, as the grinding tool is called.

Up to a certain point all lenses, those of the best or of the commonest quality, are treated alike. But for grinding the glasses to the correct form, and also for polishing, they are operated upon either singly, or several together, according to the size and the degree of accuracy required

in the lenses; the best lenses for the object glasses of telescopes being ground and polished singly, while, on the other hand, as many as four dozen common spectacle glasses are sometimes cemented upon a runner, and ground and polished at the same time. When several lenses are to be ground and polished together, the number must be such as admits of being arranged symmetrically around a central lens, as 7, 13, 21; at other times, a group of four forms the nucleus, and the numbers run 4, 14, 30. Lenses of medium quality and size are, however, generally ground true, and polished seven at a time.

In 259, the arrangement of the lenses upon the "runner" is shown.

The following is the description of the set of single lenses, 308, which serves to illustrate the relation of the focus to the magnifying power:—

No.	Foci.	Magnifying Power.
1	$\frac{1}{10}$ of inch	60 times, linear.
2	$\frac{1}{20}$,,	120 ,,
3	$\frac{1}{30}$,,	180 ,,
4	$\frac{1}{40}$,,	240 ,,
5	$\frac{1}{50}$,,	300 ,,
6	$\frac{1}{60}$,,	360 ,,
7	$\frac{1}{70}$,,	420 ,,
8	$\frac{1}{80}$,,	480 ,,
9	$\frac{1}{90}$,,	540 ,,
10	$\frac{1}{100}$,,	600 ,,

Achromatic Lenses. These were the invention of Mr. Dollond, and are produced by combining two pieces of glass, the refractive powers of which are dissimilar—as, for example, crown and flint glass. In case 274 is a good example of a mode of correcting chromatic aberration.

Microscopes. (Exhibitors 248, 249, 252, 253, 254, 257, 259, 263, 269, 287.)—The name of an instrument for enabling the eye to see distinctly objects which are placed at a very short distance from it, or to see magnified images of small objects, and, therefore, to see smaller

objects than would otherwise be visible. The name is derived from two Greek words.

So little is known of the early history of the microscope, and so certain is it that the magnifying power of lenses must have been discovered as soon as lenses were made, that there is no reason for hazarding any doubtful speculations on the question of discovery. We shall proceed, therefore, at once to describe the simplest forms of microscopes; to explain their later and more important improvements; and, finally, to exhibit the instrument in its present perfect state. The use of the term magnifying has led many into a misconception of the nature of the effect produced by convex lenses. It is not always understood that the so-called magnifying power of the lens applied to the eye, as in a microscope, is derived from its enabling the eye to approach more nearly to its object than would otherwise be compatible with distinct vision. The common occurrence of walking across the street to read a bill is, in fact, magnifying the bill by approach; and the observer, at every step he takes, makes a change in the optical arrangement of his eye, to adapt it to the lessening distance between himself and the object of his inquiry. This power of spontaneous adjustment is so unconsciously exerted, that unless the attention be called to it by circumstances, we are totally unaware of its exercise.

We owe to Mr. Lister the principles and results obtained to form a combination of lenses which transmitted a pencil of 50 degrees, with a large field, correct in every part. As this was the foundation of the improvements in achromatic microscopes, and as its results are indispensable to all who would make or understand the instrument, we shall give the more important remarks in Mr. Lister's own words:—

"I would premise that the plano-concave form, the correcting flint lens has, in that quality, a strong recommendation, particularly, as it obviates the danger of error, which otherwise exists, in centreing the two curves, and

thereby admits of correct workmanship for a shorter focus. To cement together, also, the two surfaces of the glass, diminishes, by very nearly half, the loss of light from reflection, which is considerable at the numerous surfaces of a combination. I have thought the clearness of the field, and brightness of the picture, evidently increased by doing this: it prevents any dewyness, or vegetation, from forming on the inner surfaces; and I see no disadvantages to be anticipated from it, if they are of identical curves, and pressed closely together, and the cementing medium permanently homogeneous."

These two conditions, then, that the flint lens shall be plano-concave, and that it shall be joined by some cement to the convex, seem to be desirable to be taken as a basis for the microscope object glass, provided they can be reconciled with the destruction of the spherical and chromatic aberrations of a large pencil.

Mr. Pritchard, one of whose microscopes is shown (248), appears to have made the first practical advance in the manufacture of the achromatic microscope, and his publications certainly led the way to the more efficient use of this instrument. The microscope exhibited fully exemplifies the principles enunciated by this eminent manufacturer and observer.

In the microscope (291A) is an ingenious mode of adjustment, by means of a steel chain and spindle, instead of a rack and pinion: the motion is more uniform and steady. The chain is also applied to the stage, giving an equal rate of motion in both directions, and occupying less space.

In 263 we have a compound microscope, with an achromatic prism, the invention of the exhibitors. As a substitute for the concave mirror, and for low powers, superseding the necessity of employing an achromatic condenser.

The same exhibitors have a compound microscope, with an iron stand; and another for students, of most economical construction.

The two microscopes on the table 253 exhibit the

novelty of a cylindrical fitting under the stage, provided with rack-work, for adapting all illuminating apparatus more exactly, with increased facility, and at less expense; it also admits of arrangements (in connection with polarized light more especially) which were never before applied.

The two tables (intended for the use of the microscope only) are a new mode of furnishing complete instruments. The top of each is fitted with drawers for the apparatus, and revolves, so that the microscope can be successively turned for three or four persons, who can conveniently sit round.

In the cabinet, the objects are arranged to lie flat, with the names exposed; and the porcelain labels outside, from which pencil or ink writing is easily effaced, afford a ready mode for alterations that may be required in classification.

Microscopical Illustrations. (Exhibitors 256, 306.)—The drawings exhibited explain, to persons unacquainted with the microscope, what that instrument will do; being correct representations of the respective objects when highly magnified. Some articles of food in general use have been selected; and by showing what the appearance of the pure article is, when magnified, any person possessing a microscope may easily detect any adulteration in the articles they purchase. In that of milk, the microscope may be useful, also, to assist in the selection of a wet-nurse (under the direction of the professional attendant), the milk globules being larger, and more numerous in the healthy subject. Coffee, tea, beer, &c., may be subjected to investigation, and their adulterations detected. In flour and bread a microscopist will determine whether any other grain than that of wheat has been mixed with it, and of what kind the adulteration consists; as the starch globules of potatoes, barley, beans, oats, Indian corn, &c., &c., have each some characteristic form and markings.

The microscopical structure of bone, in the several classes of animals, is not only curious but instructive.

Healthy and diseased bones have a very different appearance from each other. In a geological point of view, the microscope displays its almost magical power. If a fragment of bone, however small, be found in any of the strata of the earth, it can be satisfactorily determined to what class of animals it has belonged; whether beast, bird, fish, or reptile. That of man is different from them all, though allied to the general character of the mammalia.

The hairs of different animals have, most of them, some distinguishing character. The structure of human hair "differs greatly from that of any other mammalian animal; and, by a microscopical examination of the hairs, it has lately been determined, that some skin, which had remained for several centuries nailed on to a church door, (and which tradition stated to be that of a criminal who was flayed for committing sacrilege,) was really human skin." The scientific investigation of J. Quekett, Esq., of the Royal College of Surgeons, London, very satisfactorily proved, that the hairs on that skin are human. The account is contained in the second volume of "The Transactions of the Microscopical Society of London." All the drawings now exhibited have been taken with the aid of the camera-lucida, applied to the microscope, and the details carefully finished afterwards, by observation, under the same magnifying power. Only one instance of diseased structure has been selected—that of the human lung, when affected by consumption.

The petal of geranium (252) well illustrates the wonders of the microscopic world. The piece drawn is hardly, if at all, larger than a pin's head, and yet it shows an immense amount of the most complicated and beautiful structure, where to the naked eye nothing appears but a mere coloured membrane.

Spectacles. (Exhibitors 259, 268, 271, 273, 276, 279, 280, 283, 289, 290.)—Of these useful articles a very numerous class are exhibited. We have received many notes from the exhibitors, pointing out the particular merits of their

productions. These consist principally in the mechanical arrangements of the frames rather than in any physical peculiarity of the optical arrangements—a few only of these can be noticed.

Spectacles and reading-glasses are among the simplest and most useful of optical instruments. In order to enable a person who has imperfect vision to see small objects distinctly, when they are not far from the eye, such as small manuscript or a small type, a convex lens, of very short focus must be used both by those who are long and short sighted.

When a short-sighted person, who cannot see well at a distance, wishes to have distinct vision at any particular distance, he must use a concave lens, whose focal lens will be found thus :—multiply the distance at which he sees objects most distinctly, by the distance at which he wishes to see them distinctly with a *concave lens*, and divide this product by the difference of the above distances.

A long-sighted person, who cannot see near objects distinctly, must use a *convex lens*, whose focal length is found by the preceding rule.

In choosing spectacles, however, the best way is to select out of a number, those which are found to answer best the purposes for which they are particularly intended.

Dr. Wollaston introduced a new kind of spectacles called *periscopic*, from their property of giving a wider field of distinct vision than the common ones.

Periscopic spectacles decidedly give less perfect vision than common spectacles, because they increase both the aberration of figure and of colour ; but they may be of use in a crowded city, in warning us of the oblique approach of objects.

The improvement of the patent *Pantoscopic* spectacles is thus described by the exhibitor :—

"The painful sensation caused by rays from every passing light or object striking the surface of the glass, is altogether removed ; and, when the eye is directed upwards, no glass obstructs the object desired to be seen by the wearer.

When attention is directed by ladies to their work, or by gentlemen to the book or desk, no exertion is requisite or needed to adapt the eye to the glass, as in the spectacles of the old construction. With the head in its proper position (upright), and the book or work close to the person, no inconvenience is sustained, as the centres of the glasses are seen through: the lid rising, you see above the spectacles. Above the horizon the sight is unmolested, while below the glasses await you, resting in a plane with the book, desk, or needlework, the lid naturally *descending* to exclude the object above the level of vision."

Amidst the interesting group of optical and philosophical instruments (259) will be found a very instructive series, exhibiting the progress of the manufacture of a pair of spectacles—from the rough wire to the finished frames—from the unground piece of glass up to the completely adjusted lens. In the same group will be found many other objects well deserving attention as examples of processes of manufacture.

The greatest curiosity is a pair of spectacles (320) weighing under five grains, of exquisite workmanship.

Barometers. (Exhibitors 117, 138, 140, 149, 157, 159, 160, 161, 162, 163, 166, 259, 271, 331, 332, 396, 411, 674.)—The principle of the barometer will be popularly explained in the following remarks. As the air surrounds the whole earth, it presses upon everything, upon the land as upon the ocean. If we plunge one end of a tube into a vessel filled with water, the fluid will rise as high within the tube as without, for the pressure of the air in the tube acts precisely the same upon the level of the fluid as without the tube. But if we abstract a portion of the air from the tube, the fluid will continue to rise as long as we remove the air. By this exhaustion, the air within the tube is diminished, while the external pressure of the air remains the same.

The preponderance of the external pressure of air raises the fluid within the tube, until the weight of this raised

column of water equipoises the preponderance. If we entirely exhaust the air in the interior of the tube, the water must rise (provided the tube be high enough) until the weight of the raised column of water is equal to the weight of a column of air of the same base reaching to the limits of the atmosphere. In this manner we may ascertain the weight of a column of air, whatever be its height.

We have to thank the mechanicians of Florence for the first germ of the discovery of this important law. On trying to raise water above 32 feet in a suction-pipe they found, to their great surprise, that the fluid would not rise beyond that altitude. The rising of a fluid was explained at the time by saying that Nature abhors a vacuum; but this reason did not satisfy Galileo, who, on hearing of the observations made by the pump-makers, at once came to the conviction that the gravity of the air was the true cause of this phenomenon. His pupil, Torricelli, gave convincing proofs of the truth of this conjecture, and arrived at nearly the following results. In order that two different columns of fluid should be equipoised, it is necessary that their heights should be inversely as their densities. Mercury weighs nearly 14 times as much as water. If now the atmospheric air can support a column of water 32 feet in height, it must also, according to the above view be able to sustain a column of mercury of 28 inches in height. The experiment is easily made. We fill with mercury a glass tube of about 30 inches in length and closed at one end, and holding the finger over the open end invert it. If then we plunge the end closed by the finger into a vessel with mercury, and then remove the finger, the mercury will immediately sink some inches, until the elevation of the mercury in the tube is as much beyond the level of the mercury in the vessel, as follows from the above considerations. The column of mercury in the tube is to be regarded as an equipoise to the pressure of the atmosphere. This apparatus constitutes the barometer. The vacuum above the column of mercury is called the *Torricellian vacuum.*

In the barometers usually employed, an adjustment is required every time an observation is made. In 140, the scale is suspended from a pulley, and attached to a float in the cistern. It is, therefore, self-adjusting, except so far as friction interferes with free motion.

Under this head may be included the *Meteorological Clock* (60), which is designed to give a more correct measure of mean time, and to register the mean hourly variation of the barometer and thermometer, in permanent lines, of variable length.

The clock has a new vertical dead-beat escapement, with invariable force impulse pallets, the angle of repose of which is upon the teeth of the escape-wheel until the impulse is required. The reaction of the escapement is upon a point instead of two bearings, as in the ordinary escapement.

The pendulum has two glass rods, the inner one of which carries the bob, the outer one the compound compensating bar, in which two metals of great difference of expansion are used, each metal having a screw of the same pitch at its extremity. This entirely new arrangement gives a micrometrical adjustment for temperature. The meteorological attachment is very ingenious. The barometer and thermometer are kept vibrating by the clockwork, and as they vibrate, the variation in their radii of gyration is affected by temperature, or by the pressure of the air: the number of vibrations, more or less thus affected, corresponding to the height of the barometer, &c., are registered by a line, which is drawn on a paper placed upon a cylinder, the marks being fixed upon a rod in connection with the hour-wheel of a clock which, by descending the 20th of an inch each hour, determines the length of line.

The inventor says:—"The baro-gymeter (barometer) and thermo-gymeter (thermometer), though attached to the gyrometer, as the instrument is named in the present instance, may, if required, be detached, and placed at any

distance, even to that of a thousand miles from the place of observation, and still the variation in the barometer, to a far greater nicety than by actual observation, may be transmitted and permanently registered, the electric wire being the means of communication;" but he has not informed us by what means this is to be effected.

The Sympiesometer. (160A.)—This instrument was the invention of Dr. Hooke. It consists of two parts—one is a common spirit thermometer, and the other a tube filled with coloured water and air. The open end of this tube is immersed in water of the same colour contained in an open vessel, so that it is exposed to the pressure of the atmosphere. This last part of the instrument will be affected not only by the atmospheric pressure, but also by temperature. The heat will dilate the air in the upper part of the tube, and by that means drive the water downwards, while the pressure will force the water higher up in the tube.

If, at the time of the formation of these two instruments, their zeros were marked at the same point, the gravity of the external air remaining the same, their indications would be found exactly to correspond; so that if a difference in their indications took place, that difference could be ascribed only to the alteration in the atmospheric pressure upon the surface of the water in the open vessel. In proportion, therefore, as the difference between the two is greater or less, so is the alteration in the gravity of the air, from what it was when the instruments were first graduated. For instance, when the water in the tube stands above the division which corresponds to that to which the spirit points, it is an indication that the atmospheric pressure is greater at that time, than it was when the instruments were graduated, and *vice versâ.* This double instrument is more useful at sea than the common barometer, as not requiring a steady position, and it may have its scale of variation considerably enlarged by making the bore of the tube very small in proportion to the capa-

city of its head. But experience has shown, that when this double instrument has been kept long, the included air loses somewhat of its elasticity; hence, in process of time, the water stands higher than it ought, and therefore indicates the gravity of the atmospheric air to be greater than it really is. The construction of the sympiesometer has been improved by different artists; but from the liquids changing their states, and thereby producing an incorrect indication, it is not so generally used on shipboard as the marine mercurial barometer.

The Aneroid Barometer. (Exhibitors 55, 137.)—This instrument appears to have originated with M. Conté, who published a paper on it in the 'Bulletin des Sciences, Floreal, An 6.' This contrivance was essentially as follows: —A bowl made of strong iron or copper was fitted with a cover of thin sheet steel, the edges of which fitted with extreme accuracy. Springs were placed on the inside to keep the cover at its proper elevation, and the air is pumped out of this bowl. Now, as the resistance of the springs remains the same, this cover-plate rises or falls as the atmospheric pressure varies, and these variations are shown by means of a hand, securely fastened, which moves backward and forward upon a divided plate. M. Vidi's aneroid is, in principle, the same; it is an air-tight box, from which the air is exhausted, so that it is pressed by the atmospheric column.

A few words may be required for the further illustration of this subject. We know that the atmospheric pressure is about 15 lbs. to the square inch. Now the vacuum-vase being 2½ inches in diameter, this surface gives for its product a pressure of about 73 lbs. on the vase; though from many causes, this amount of atmospheric pressure is considerably reduced. In order to ascertain the actual weight produced by the atmosphere upon the surface of the vacuum-vase, recourse was had to an experiment, affording positive demonstration. The hook of a steel-yard, or spring weighing-machine, was attached to the upper part of the

vase, and, on being pulled up to the point parallel to the top of the vase, showed the weight of 44 lbs.; which was, therefore, proved to be the force by which the aneroid barometer was compressed.

This instrument is now very generally and satisfactorily employed for many purposes beyond that of merely indicating changes in atmospheric pressure.

By the application of this elegant little instrument, an opportunity is afforded the traveller of learning the level of the railway along which he is passing, even at the utmost speed of the engine. It must be allowed, at least, that no *mercurial* barometer can accomplish *this* purpose. The tourist may, by the same means, as he is ascending Snowdon, Ben Lomond, or Mont Blanc, observe the delicate movement of the hand of the aneroid as he ascends.

An amusing experiment for showing the delicate sensibility of the aneroid, and its power of measuring small heights, may be tried in an ordinary dwelling-house. Any one, on ascending from the basement to the attic, will perceive the gradual approach of the index, and its return to its original position, whenever he descends from the attic to the basement. The tenth of an inch is subdivided on the face of the aneroid into four parts: and generally speaking, if the hand goes back one-tenth of an inch, we may fairly conclude that we have ascended from our starting-point about eighty-five feet; and, of course, *vice versâ*. Calculations should be made according to this proportion.

But to no class of persons will the aneroid offer advantages so great and so pre-eminently important as to the mariner, when we consider the life and property intrusted to his care, and the influence of the atmosphere on his safety. He knows too well, by experience, not only the tardy indications he is forced to be content with, from the sluggish action of the barometer in general use, but the difficulty of reading off those indications with exactness, when the vessel is in considerable motion. The aneroid, on the contrary, responds in a moment to the influence of

atmospheric pressure; and this it does without any oscillation of the hand, that may occasion the least doubt in the observer. Nothing is more common than a sudden variation of atmospheric pressure to the amount of nearly half an inch on the barometer. To point out this would, in the ordinary instrument, inevitably occupy some minutes, while the mercury was forcing itself up or down the capillary tube towards the point which is to give indication. As an exemplification, it may not be amiss to lay before the nautical man the case of his being, while in his cabin, made sensible, by means of the aneroid, of a sudden change likely to take place in the state of the atmosphere. An important alteration might be immediately necessary in the adjustment of sails, &c., which, by the timely information afforded him through the aneroid, he would at once have accomplished, long before the common marine barometer had even signified the coming change. Instead of being obliged to proceed backwards and forwards from the deck to his cabin to consult the mercurial barometer, he remains on deck with the aneroid in his hand, and is immediately certified of every atmospheric variation while he is issuing orders to the ship's company.

The Barometer of Mines. (411.)—Explosions in collieries will not be prevented by merely hanging a barometer in the pit; but they will be reduced in number, and greatly weakened in fatal effect, by augmenting habits of philosophical observation in the mine; and one of the most essential points of this observation is, to look well to the rising or falling of the barometer in the mine.

This instrument acts by the pressure of included air against the atmosphere. By adjusting the capacity of the air cistern, the scale may be chosen *ad libitum*, and may exceed the common scale of barometer as much as may be desired; but three or four inches to one, in the common kind of instrument, is enough.

The temperature of a deep mine (deep mines are now to be pronounced free from chance of explosion) is nearly

invariable at a given point—a correction for temperature is really not required; but a rough scale for this purpose is put to the tube, we suppose, to show that the inventor knows what he is about. It will not be wanted in a deep mine, and ought not be put, except for the general purpose of improving the habits of mind of the over-men. The merit of the instrument is its cheapness, portability, large scale, and express adaptability to carry out suggestions of humanity.

The Electrophorus. (411.)—In the ordinary instrument, which bears this name, the excited resin will communicate no removeable charge to the cover, unless, after contact is made between cover and sole, the former be touched by a conductor, usually the finger—a troublesome process, which banishes the instrument from use. In this instrument, that inconvenient process is replaced by a fixed conductor through the resin to its metallic base; and by this arrangement, (which suggests a very elegant problem of electrical tension,) the charge becomes renewed, and is removeable as often as the cover is lifted, discharged, and replaced. It will give sparks 2 inches long, if properly excited; and retain excitement for a long period of time.

The Maximum Thermometer. (411.)—The ordinary instrument, so called, is inevitably a coarse and clumsy thing, totally unfit for delicate research, because the bore of its tube must be large enough to carry a wire. The frequent disorder of the instrument is well known.

These defects are obviated entirely by making a very fine bore, and making the thermometer in the usual way of accurate calibration; then, by blowing a second bulb, the means of separating a little column of mercury, and keeping it separate by a small quantity of attenuated air interposed, are obtained The column may be chosen of any length, and separated much or little. It will work well in every position, will never get disordered, and will record thermometrical differences of extreme delicacy, such as the temperatures of the coloured rays of the spectrum, which

have actually been measured, with great success, by an instrument not half so large as the one sent for example. The little column will not go back to its place by mere tapping ; it is better to swing it.

The Anemometer.—The instruments of most reputation in researches on wind are best fitted for high velocities, and quite inapplicable to low currents of air in collieries, hospitals, and ordinary apartments. Among many methods by which when engaged, by direction of Government, on a Colliery Commission, the inventor succeeded in measuring these low currents, he thinks none so applicable to variety of current and situation, and so likely to be well handled by practical men, as this. From its construction, it will be evident, that on it the force of wind is most accurately measured, by being weighed against the force of gravity, in the light semicircular vane : that the force of wind bears to gravity the largest proportion in the lowest velocities ; and thus it satisfies the want of a correct indicator of low currents. It has been found by trial, in company with Dr. Arnott and Mr. W. Harcourt, perfectly adapted to determine the amount of ventilation in the newly-erected county hospital at York. The calculation is effected by inspection of tables, involving only the arguments of weight of vane, and angle of deviation from the vertical. The values of the degrees of deviation are written on the instrument, and by this it may be tried.

The Rain Gauge. (Exhibitors 396, 411, and 674.)—The object of the instrument 411, is to register the rain which falls in such a manner, that the direction in which it comes, and the angle of inclination from the vertical, in which it descends, may be known, as well as the quantity which falls on a horizontal surface.

This last is the only thing which a common rain gauge teaches ; but, for refined and accurate researches on rain, it is very important to have the other data, which no other rain guage has ever proposed to give. It has been made in different forms, and all succeed ; but the one exhibited is the most approved.

The quantity which falls on a horizontal surface is collected in the funnel, and passes down to the cock placed at one angle of the base. There are four side-funnels, with vertical edges: the rain which falls in each passes down to a separate cock.

A glass graduated measure is employed in completing the observation. Suppose the instrument placed with its face N. north-east, and that the rain comes from some part between north and east, and not quite vertically, there will be some rain in N., and in the funnels facing N. and E. Then, by a simple computation—comparing the quantities in N. and E. funnels—we find the direction between north and east, in which the rain came; next, by comparing these quantities with that received in the horizontal face, we easily determine the angle of inclination at which the rain descended. This is best done by tables, and is accomplished by inspection quite easily. It should be done after each shower, or set of showers.

The other rain-gauges are rendered self-registering by ingenious contrivances.

A Block of Marble. (411.)—This is a piece of common magnesian limestone, coloured by metallic oxides, exactly as nature colours her marbles. It is varnished with a varnish which stands heat.

The Storm-pointer. (322).—The typhodeictor, or storm-pointer, is an instrument for obtaining, by inspection, the bearing and relative position of a revolving storm or hurricane, constructed in accordance with the theory, commonly called the law of storms, as made known in several publications by Colonel Reid.

It is now a well-ascertained fact that great storms have a rotary motion like whirlwinds. The theory, commonly called the law of storms, as made known in several publications by Colonel Reid, has been established from thousands of well-authenticated observations in different parts of the world, and extending over several years. It proves that in a gale of wind near to the tropics the winds blow with the greatest fury round a common centre. At this

centre there is little or no wind, even a perfect calm, but generally, on the ocean, a terrific and confused sea.

The most violent and dangerous part of these revolving gales is somewhere near this central calm, the wind there blowing the most fiercely, acquiring, it is stated, a velocity of even 100 miles per hour. These storms sweep both land and sea in certain parts of the globe; their tract and directions are pretty well known; and they travel from their birth-place to their destination at variable speeds; sometimes not more than at the rate of four to six miles an hour, although the wind within their range is blowing round with the fury already indicated.

If a ship unhappily becomes entangled within the range of these terrible gales, she is in great peril; many have foundered, and others have pursued their fearful course round and round until they have been reduced to helpless wrecks, dismasted and water-logged. Then, and then only, does the gale slowly pass over and away from them.

In the northern hemisphere, these winds blow round the compass from east-by-north to west, on the contrary way to the hands of a watch; whereas, in a southern hemisphere, it is just the reverse, blowing round as the hands of a watch would go.

On these most valuable data, instructions have been drawn up by Colonel Reid, and others, how to ascertain the relative place of a gale, so as to know whether it is approaching or going from a ship, travelling by its side, or passing across its path.

Thus, an intelligent mariner, taking these maxims for truth, will be able not only to avoid the fury of this terrible enemy, but can make it even subservient to his purpose, and often take advantage of it as a fair wind. The object of the instrument is, by graphic illustration, to show the means of avoiding danger and destruction.

The Dipleidoscope. (55).—This useful little instrument will be as perfectly understood by the following remarks made by the inventor as it is possible, without the use of diagrams: —"The time," in popular language, denotes a certain divi-

sion of the day, calculated from the sun's appearing at its greatest or meridian altitude at any particular place. When the sun has reached this altitude, it is mid-day or noon. The day, that is the time occupied by the earth in making one complete revolution upon its axis, is divided into twenty-four parts, or hours.

In the course of this revolution, every part of the earth's surface must have been directly opposite to the sun; or in language more scientifically correct, must have had the sun in the plane of its meridian: and the moment at which any particular place was thus directly opposite to the sun, was noon to the inhabitants of that place.

Hence it will be seen, that the word "noon" is a relative term, and that of any two places situate in different longitudes, noon will be earlier at the place which lies nearest to the east. If the distance be fifteen degrees of longitude, the difference will be one hour; and so more or less in proportion.

To determine at all places the period of noon is the object of the dipleidoscope.

The following familiar illustration is introduced to further explain the optical construction. When the sun is about setting, it is not uncommon to see the rays so reflected from the windows of a whole range of houses, as to convey the idea of a public illumination. While some portions of the sun's rays are thus reflected, other portions pass through the glass into the rooms. The rays thus transmitted (the rays of *incidence*, as they were styled above) may be reflected at pleasure in any direction consistent with the range of the sun, by a person within the room, having a looking-glass in his hand. Now if, instead of throwing the rays upon a non-reflecting object (such as the wall, &c.), he were to transfer them to another looking-glass, they would be again reflected from this latter glass. Supposing these two looking-glasses to be placed at an angle of less than 90 degrees, in a manner corresponding with the position of the two silvered planes seen in the instrument, he can reflect the sun's rays again out of the

window. Now, if we imagine the window to represent the outer reflector of the meridian-instrument, its construction is, by this process, completely exemplified. To proceed a little further: it is evident that the angle and situation of the two looking-glasses could be so arranged as to direct the rays of the sun through any particular pane of the window; so that a person standing without, in a proper position, would see, in addition to the sun's rays reflected from the *outer* surface of the pane, the rays of incidence that had passed through the window, and were thus reflected from the double mirror. One of the luminous objects (the flash or glare of the sun) so produced, would be reflected from the surface of the window, and would be a *single* reflection; while the rays of incidence, which had passed through the window, and undergone a *double* reflection by means of the *two* mirrors would, on being thrown back by the mirrors through the window, move in a direction contrary to that taken by the single reflection from the surface of the window-pane. Hence, any one of the heavenly bodies, subjected to the eye by a process of the above description, would not only appear as two distinct objects, but those objects would be seen to approximate and cross each other in an *opposite* course: a desideratum being hereby secured which increases the power of the instrument in a double ratio.

Balances. (Exhibitors 324, 333, 334, 341, 344, 358, 367, 368, 671.)—The common balance or weighing beam consists essentially of a rod called a beam, which revolves round a fixed horizontal axis inserted in its centre. When there is no load at either end, the beam should be in a perfectly horizontal position. To either end of the beam common scale-pans are suspended, which serve for the reception of the bodies to be weighed. If both pans are equally loaded, the beam will retain its horizontal position; but if an unit of weight is laid upon one of the pans, the beam will incline towards that side.

We will now inquire how the conditions above men-

tioned can be satisfied. If we first suppose that the scale-pans are removed, and assume that the horizontal axis passes through the centre of gravity of the beam, we shall have a case of indifferent equilibrium, and the beam will be in equilibrium at any angle with the horizon. Such an arrangement will not therefore fulfil the first condition, namely, that the beam should assume a horizontal position before the pans are loaded. This condition can only be fulfilled, if the centre of gravity of the beam lie below the fulcrum.

If we draw a line at right angles with and bisecting the longer axis of the beam, this line must pass through the fulcrum of the beam, and through its centre of gravity.

The principal points to be attended to are:—

1. *The centre of gravity of the beam must lie as closely as possible below the centre of suspension.*

2. *The sensibility of the balance increases with the length of the beam.*

3. *The beam must be as light as possible.*

In the delicate assay balances exhibited, these have been most carefully attended to, and the results are the production of balances of the most extraordinary accuracy.

333 and 334 are remarkably fine examples. The latter maker exhibits three balances; one with a beam 3 feet long, adjusted to carry $\frac{1}{2}$ cwt. in each pan, and when thus loaded, still weighing to $\frac{1}{10}$th of a grain. The beam of the second balance is 16 inches long, to carry 2 lb. in each pan, and indicating $\frac{1}{100}$th of a grain. The third balance has a beam 14 inches long, to carry 1,000 grains in each pan, and turn with $\frac{1}{1000}$th of a grain.

The construction of the beams of the three balances is that with three straight knife edges; the centre resting upon a plane, and the pans also being suspended upon the beam by planes.

In the two smaller balances, the one to carry 2 lb., the other to carry 1,000 grains in each pan, the three knife

edges of the beam are made of agate, whereby the instrument is protected against the attacks of any vapours that would affect the steel edges, which is very important for use in a laboratory.

Sovereign Weighing Machine.—In connection with the balances, we must not forget to direct attention to *Cotton's Weighing Machine*, which has been extensively employed in the Bank of England, and a specimen of which has recently been placed in the Western Avenue; it separates those coins that have, from those that have not, a certain assigned weight. A pile of coins being placed in a tube, the lowest is pushed out by a lever and deposited on the end of the beam, which, if the coin is of full weight, is depressed through a small space, but if it be too light, the beam remains stationary. A small piece of steel now advances from one side, on a level with the position that a heavy coin assumes, and immediately afterwards another advances from the opposite side, on a level with the position of the light coin. If the coin has full weight, the first advancing piece pushes it into a receptacle, and the second has no effect; if, on the contrary, the coin is light, the first passes under it, and the second strikes it into another receptacle. In actual use, these operations are performed with great rapidity.

The Magnetic Balance. (377.)—The beam of this instrument is a magnet, and its position is governed and adjusted by the repulsive action of two other magnets in the lower part of the instrument, which turns and may be adjusted to any angle by the graduated circles. The scale-pans are formed of slight silver foil, and suspended from the beam by single fibres of unspun silk; they are, together with the beam, separated from the other parts of the instrument, by slight partitions, to avoid the effect of currents of air; and the weights and materials are put in at the sides, where there are sliding glass-doors. It will be evident, that the article, of which the weight is sought, is here weighed against the force of magnetism, instead of

that of gravitation. The advantages which it is stated this balance possesses over the ordinary balance, are, extreme sensibility (it being capable of indicating much less than the ten-thousandth part of a grain), and the facility with which its indications are obtained for exceedingly minute quantities.

Miner's Theodolite. (402.)—This instrument is essentially different from the common dialling instrument, inasmuch as it consists of two plates, fitted up so as to revolve one upon the other by means of rack-work, on the principle of the land surveyor's theodolite; which contrivance furnishes the practical miner with the means of measuring all his horizontal angles by a vernier scale, without trusting to the needle. This is of great importance in modern mine surveying, as it is often found that the presence of iron, such as pumps, railways, &c., renders the needle useless.

The limb is divided so as to read off the angle from the points of the needle, as in the common miner's dial. It also enables the operator to do so with greater accuracy from a vernier scale attached to the outer ring, and moving over the outer extremities of the same divisions.

The quadrant consists of a semicircle of brass, with a traversing limb, to which are attached common sights, and a telescopic level. The sights and telescope are not used together, but are so constructed that two small thumbscrews will disengage the one and attach the other. The instrument is complete without the telescopic level, that being principally used for surface surveying, levelling, &c.

Under the plate of the dial there is a small brass peg attached to a cord, which must be drawn out to allow the dial to revolve by the rack. When this peg is inserted, it can only be used as a common dial, and the rack must not be worked. There is also under the plate a small brass slide, which must be drawn out a little to give freedom to the needle, but which should always be pushed in when the instrument is not in use, that the centre and agate may be protected.

The vernier scale to the limb of the dial reads to two minutes, or the thirtieth part of a degree.

This exhibitor has several other very ingenious surveying instruments, which our space will not allow us to describe, with the exception of—

Fox's Magnetic Dip and Intensity Instruments, which are too important and too highly valued to be neglected.

A full description of this instrument will be found in the 'Reports of the Royal Cornwall Polytechnic Society,' to which those interested are referred. It is, of course, well understood that a compass needle, a magnetised bar of steel, being mounted, free to move upon its centre, is drawn out of the horizontal line, and it is depressed or *dips* towards the earth. This is caused by the power of terrestrial magnetism. Such a magnetic bar would swing perfectly horizontal at the equator, and would exhibit a gradual increase in the amount of depression as we proceeded towards the poles, until at the magnetic poles it would hang in a vertical direction. The angle which the needle makes with the horizontal plane is called the *dip of the needle*. The intensity of the magnetic force is known by the use of *deflectors*, or steel bars magnetised, by which of course the needle is deflected. The relative intensity of terrestrial magnetism is found as follows :—

The instrument is in the plane of the magnetic meridian; one of the deflectors is screwed into arms which are on the back of the instrument, and made to coincide with the direction of the dip, when the needle will be repelled from it; mark the angle to which the needle points at both ends (after repeated vibrations produced by rubbing a point at the back connected with the jewels on which the needle is mounted), then cause the needle to swing back to the other side of the dip, and note its place as before: half the sum of the angles to which the needle is thus deflected (or rather of their sines) will represent the relative force of the terrestrial magnetism, at different places, on a needle thus circumstanced.

Observations on the intensity and dip may be made *without the deflectors*, by weights only suspended over the groved disc fixed on the axis of the needle. This method is too obvious to require a minute description; the weights in this case being used to produce deflection from the dip at any place instead of the magnetic deflectors, the weights required to cause a given amount of deflection being taken as the relative measure of the magnetic intensity at the place of observation.

In one case, the magnetic deflectors are made the force by which the needle is drawn out of its true position; in the other, weight or gravity produces the same result; and as the intensity varies, it is evident a greater or a less force is required, and the variations of magnetic intensity are thus indicated.

These instruments have been long employed in our surveying vessels. In the Arctic voyages they have been constantly used; and in Ross's last South Polar voyage magnetic observations at sea were made with very decided advantage.

Magic Lanterns—Phantasmagoria. (Exhibitors 161, 270.) —The magic lantern was invented by Kircher. The light of a lamp, reflected from a concave mirror, is concentrated by a lens, a short distance in front of which is placed the picture painted on glass in transparent colours; the rays thus coloured by passing the different chromatic media, permeate a second plano-convex lens in front, and an enlarged image is thrown upon a properly-prepared screen. The *phantasmagoria* is nothing more than this; and the arrangements for dissolving views consist either of two lanterns so adjusted that one lenticular image can be thrown out of focus, while the other is gradually brought into focus, or of two tubes in the same lantern, which are capable of similar arrangement. The improvement which has taken place in the slides for magic lanterns is very great. Many of the views exhibited (270) will be found to possess artistic excellencies of no mean order. An in-

spection of the geometric forms constituting the *chromotropes* will show the manner in which the involved, and often magical, tracery of curves is produced in those exhibitions of them with which the public are now rendered tolerably familiar.

Trinoptric Lantern. (263.)—This lantern consists essentially of a square metal box, into three sides of which are fixed the tubes containing the lenses, and to the two side tubes are affixed mirrors, which are capable of adjustment to any angle. It will be easily understood that by these means we may have either three distinct pictures on the screen at one and the same time, or that they may be easily made to blend, or pass one into the other; thus affording means by which a series of "dissolving views" may be produced without any of the annoyances which arise from the use of two or more lanterns.

The imperfection in the trinoptric lantern as above described lay in the use of reflectors, from which there was considerable loss of light in the side tubes; and although with the oxygen and lime light, invented by Mr. Beechy (to be presently described), the pictures were clear and good in a twenty-feet disc, yet it was advisable to choose the lightest pictures for the sides, reserving the darker ones for the front. The double surface of glass mirrors also prevented that sharpness and clearness of detail which it is desirable to preserve. The use of prisms instead of mirrors was suggested; but the narrow limits under which the reflection from prisms is confined, rendered it very difficult to get even two perfect discs to be coincident with any high power. This will be apparent when the conditions of perfect reflection from prisms is considered. The reflection obtained at the correct angle is the most perfect possible, but it is only when the incident ray is less than 41° 50′ that reflection is perfect; at any greater angle the light passes through. If, therefore, the back of a reflecting prism be inclined at the angle of 45° or 46°, which was necessary in the old trinoptric, in

order to obtain coincidence, it will be evident that part of the disc will be imperfect; and if, in order to remedy this, the back of the prism be inclined much further back, the disc will never agree with that from the front tube, and there is, moreover, the danger of some of the rays of the pencil missing the back altogether, and so spoiling the other side of the disc. Thus, the limits within which such a prism can be employed are very narrow. The front and back of a circular box being firmly fixed to the top and bottom, but having the sides on which the other tubes are fastened moveable by a circular groove and tongue in the top and bottom, so that the two side tubes may be inclined to the front tube at any angle from 66° to 100°; between the sides and the front and back there are diaphragms of black leather, bent like the bellows of an accordion to allow of the angular movement, and yet prevent any light from escaping.

The front slides are put in from above, which is found to be even more convenient than in the former arrangement. The front lever, which opens and closes the shutters, is bent to allow of this, and is moveable about a ring round the chimney, whilst a semicircular space in the top above the centre tube allows of the motion of the cranks of revolving slides. Now, the lights being placed in the centre of such a box, it is clear that it will, at whatever angle the tubes are inclined, prove true with respect to the light. When the side tubes are placed in such a manner that they form with it an angle of 68°, or even less, this will allow of the back of the prism being inclined so much less that the angle of incidence shall be sufficiently small, and a perfect disc obtained of 7 feet diameter at 12 feet distance, with a plain right-angled prism; and if a lenticular right-angled prism be employed of about 30 inches focal length, the diameter of the disc will be increased to 9 or 10 feet. This is sufficient for every ordinary purpose, giving a 20-feet disc at 24 feet diameter, perfectly bright, and only a very slight imperfection at the side furthest

from the centre, owing to the lenticular side sloping a little from the direct axis of light.

In order, however, to remove this last imperfection, Mr. Beechey has had constructed a prism, which he believes will be found of the most perfect form.

Thus constituted, the prismatic trinoptric lantern becomes a very perfect instrument for lectures and exhibitions. The pictures produced by the sides are equal to those of the front. Three perfect lanterns are in the hands of the operator at once, which can all be made to bear upon one point, producing the most beautiful dioramic effects. A single light, whether the oxygen and lime lamp or a small camphine or good solar lamp, according as the exhibition is large or small, is all that is required, though the oxygen and lime light is greatly to be preferred, as free from heat or smell, and so very superior in intensity.

The trinoptric and dioptric prismatic lanterns, within less compass than a single lantern of the ordinary construction, combine all the powers of two or three distinct lanterns: with only one small lamp of intense brightness, a perfectly-defined disc of 20 feet from each tube may be obtained; the discs, by means of the prisms, may be united to produce perfect coincidence, or at various distances. The lamp is on the fountain principle, with a small circular wick: a small tube passes through centre of the wick, for the purpose of supplying oxygen gas, by which an intense light is produced, nearly equal, in illuminating power, to the oxy-hydrogen of Drummond.

Mechanical Figure. (210.)—This curious piece of mechanism is intended to illustrate the different proportions of the human figure: it admits of being expanded from the size of the Apollo Belvedere to that of a colossal size.

The external part of the figure consists of a series of steel and copper plates sliding upon each other, and kept in contact by screws, nuts, and spiral springs; attached to these plates, and within the figure, are metal slides, having projecting pins at their extremities; these pins are inserted in curved grooves cut in circular steel plates;

the curvature of these grooves being so arranged that when the steel plates are put in revolution by a train of wheels and screws the slides belonging to each particular part of the figure are expanded or contracted in correct proportion. The elongation of the figure is accomplished either by sliding metal tubes, provided with racks, and acted upon by a combination of wheels, or by screws and slides, as found most applicable for each particular part. The varieties of figure and size of the human body are so numerous that it necessarily requires a great number of movements to represent them. Some idea may be formed of the number of mechanical combinations included in the figure, from the following list of the parts of which it is constructed, viz.—875 framing-pieces, 48 grooved steel plates, 163 wheels, 202 slides, 476 metal washers, 482 spiral springs, 704 sliding plates, 32 sliding tubes, 497 nuts, 3,500 fixing and adjusting screws, and a considerable number of steadying pinions, &c., making the number of pieces, of which the figure is composed, upwards of 7,000. It is stated that this invention could easily be made applicable in the artist's studio; but that its more immediate object is to facilitate the exact fitting of garments, more especially in cases where great numbers are to be provided for, as in the equipment of an army, or providing clothing for a distant colony; that personal attendance is not required, since there is adapted to the figure a new system of measurement which enables any person to take the exact size and form of an individual; and from the measurement so taken the figure can be adjusted to represent correctly the person to be fitted, so that the clothing may be tried on, and, if necessary, altered with as much facility as if the original person, whose measure had been taken, were present.

An establishment provided with three or four of such figures, would be sufficient to fit perfectly, and without any subsequent alteration, the clothing of an army of several hundred thousand men, at whatever distance they might be from the establishment.

Class X.—Philosophical, Musical, Horological, and Surgical Instruments. Division 2.

Electric Clocks. (Exhibitors 17, 128, 434.)—A clock may be divided into two parts: the pendulum which measures the time by its vibrations; and the hands which register the number of such vibrations made. With regard to the pendulum, one of two things must be attained—it must either be isochronous, or the power applied to keep it in motion must be equal. The isochronism of a pendulum depends upon its free motion.

This rule applies to all clocks; and, if it be attended to, it matters not what motive power is employed.

In the first electric clocks, the pendulum-rod carried, at its lower extremity, a hollow coil of wire, vibrating over two bar-magnets. The break was supported on two brackets, and was moved backwards and forwards by an arm projecting from the pendulum. The pendulum, as it vibrated, alternately made and broke the contact, causing the coil to attract the bar-magnets over which it vibrated, and which imparted the necessary power to keep it in motion. This is the construction of Mr. Bain's clocks (434), to whom we are deeply indebted, as first applying the power to measure time.

In all the electro-magnetic clocks made before the example in the Transept and 128 in this class, the attractive and repulsive forces of magnets have been applied directly to the pendulum, as just explained; consequently, any variation in the intensity of the electric current will produce a corresponding variation in the motion of the pendulum, which, as it vibrates, has to move the hands of the clock, as well as the slide break, at the end of its vibrations.

If, instead of applying the magnetic power directly to the pendulum, it were employed on the principle of the remontoir escapement, to bend a spring to a certain fixed extent during each vibration, which spring, in unbending, should give the necessary impulse to the pendulum, the pendulum would thus be totally independent of variations in the electro-magnet, that power being simply employed to bend the spring.

In Mr. Shepherd's application of this principle, the pendulum is suspended from a triangular framing, and vibrates through a hole in the bed-plate, on the opposite end of which is fixed a steel spring reaching along the bed-plate to the side of the pendulum. This spring is limited in its motion by two screws. On one side of the bed-plate is secured an electro-magnet, its poles approaching very near to one another; on the spring opposite the poles of the magnet is fixed a piece of iron, on which the attractive force of the magnet is exerted when required to bend the spring. The spring, when bent by the magnet, is held by a detent, and cannot return until the detent is lifted out of the way. Through the pendulum-rod are passed two screws: one with a flat termination, to receive the pressure of the impulse-spring; the other having a conical termination, to act as an inclined plane to lift the detent: the former we will call the impulse-pallet, and the latter the discharging-pallet. A delicate spring, insulated on ivory, is so situated that at each vibration to the right its point shall touch the side of the pendulum-rod close up to the centre of motion.

Suppose the pendulum to be in the course of its vibration to the left, the discharging-pallet lifting the detent releases the impulse spring, which immediately falls against the impulse-pallet. The pendulum having arrived at the extent of its motion, returns; the impulse-spring following it, presses it forward by its elasticity until stopped by the banking-screw. As the pendulum continues its motion to the right, it completes the circuit through

the coils of the electro-magnet, by contact with the insulated spring before mentioned.

The electro-magnet attracts the piece of iron attached to the impulse-spring, which is in consequence bent, and passes the end of the detent. The pendulum, commencing its motion to the left, breaks contact with the insulated spring, the electro-magnet no longer attracting the piece of iron attached to the impulse-spring, the latter would return if not prevented by the detent, which holds it until raised by the discharging-pallet; when the pendulum receives another impulse, the spring is again bent, and so on for each vibration of the pendulum.

This pendulum was found to vary in time, on account of the residual magnetism holding back the impulse-spring.

To overcome this difficulty, a second spring was fixed to the same bracket, beneath the impulse-spring and parallel with it; the armature which the magnet attracted was attached to this spring instead of to the impulse-spring. In the end of the stem of this spring a brass pin is fixed, rising up by the side of the impulse-spring. The electro-magnet attracts the piece of iron attached to the lower spring; but, in consequence of the brass pin in its point, it cannot be bent without bending the impulse-spring at the same moment. On the cessation of the power of the magnet, the elasticity of the lower spring overcomes the residual magnetism, and returns with the iron attached to its original position, leaving the impulse-spring locked upon its detent, ready to give the impulse, uninfluenced by either the power of the magnet or its residual magnetism.

The main advantage of this method of actuating a pendulum over all previously proposed is, that an excess of power may be employed, which is absolutely necessary with electro-magnetism, while at the same time the pendulum receives a perfectly regular accession of power each vibration.

The method which answers best for moving the hands

of small clocks is that of attraction and repulsion. A pair of pallets taking into the teeth of the escape-wheel are fixed upon an axis, on which are also fixed two bar-magnets, beneath the poles of which are placed two electro-magnets. These are caused alternately to attract and repel the bar-magnets, thereby imparting an oscillating motion to the pallets, which act in the teeth of the escape-wheel and drive it forward: the motion thus produced is carried through a train of wheels in the ordinary manner. In producing the required electric currents, two contact-springs and two batteries are employed; the contact-springs are mounted on an ivory bracket, one spring on each side of the pendulum-rod, with which their points make contact close up to the centre of motion, at the end of the vibrations of the pendulum each way. The batteries are arranged in connection with these springs, so that the circuit of each battery shall be in a contrary direction to the other. Consequently, as the pendulum vibrates to the right, it completes the circuit of one battery: the electricity passing through the coils of the electro-magnets they cause one oscillation of the bar-magnets. On the opposite vibration of the pendulum, it makes contact with the opposite spring, the battery in connection with this being arranged in a contrary direction to the former; the electricity passes through the coils of the electro-magnets in a contrary direction, causing an opposite oscillation of the bar-magnets, and consequently of the pallets, which, operating on the teeth of the escape-wheel, drive it forward.

This method of using attraction and repulsion has two advantages. It admits of electro-magnets being used of such size, that about 2,000 feet of wire may be wound upon them, which effects a great saving in the batteries. It also insures great certainty in the action with the smallest possible power, since the power applied to move the pallets is nearly equal throughout the extent of their motion. By using two batteries, reversed currents may be produced

with only one spring on each side of the pendulum, while to reverse the connection of one battery, two springs would be required, which would be more disadvantageous

By inspecting the apparatus after reading the above description, the striking arrangements will be readily understood.

Electric Telegraphs. (Exhibitors 126, 201, 419, 421, 427, 428, 430, 432, 434, 435, 436.)—If a compass needle is held above and in the same line with a wire along which an electric current is passing, the needle is deflected to the right or the left hand according to the direction of the electrical disturbance. When the connection with the source of electricity—the voltaic battery—is broken, the needle returns to its original position. Upon a knowledge of this fact, first observed by Œrsted, depends the most important of all scientific applications—the electric telegraph.

A *galvanometer* is an instrument (659) formed by coiling up a considerable length of copper-wire, and hanging in the middle, or above the bundle, a magnetic needle. The current passing through *the coil*, exerts a greater force upon the needle, and thus weaker disturbances are rendered sensible. Supposing the terminal wires of the galvanometer to be many miles in length—we will suppose them to extend from London to Liverpool;—connection is made with the voltaic battery in London, the galvanometer being at Liverpool, and the needles are deflected, N being to the right hand of the observer: if the connection is broken, the needle returns to its zero; and if again the wires are connected, but so that the current may pass in an opposite direction, the needle will again deviate, but N will now be to the observer's left hand. Numerous mechanical contrivances have been introduced, many of them of the utmost value in practice, which it would be out of place to describe in this work. In some arrangements the signals are imparted by means of an electro-magnet, which attracts and repels an arma-

ture, the motion of which is communicated to a toothed wheel, moving the index-needle from letter to letter on the dial.

Travelling by railway, we see a number of wires fixed on poles, by being passed through peculiarly shaped stoneware cylinders; these are for the purpose of insuring the perfect insulation of the wires, since, but for this, the electricity would pass down a damp pole to the earth, and the power of communication be lost. Formerly one wire conveyed the current from the battery, on one side, to the galvanometer at a distance, through which it passed, and then returned by another wire back to the battery. In 1837, Steinheil showed that the returning half of the wire might be dispensed with, and that the *earth itself* would perform the function of the wire. All that is necessary is, that one short wire from the voltaic battery at one end of a line, and from the galvanometer at the other, should be sunk into the moist earth, and there connected with a mass of conducting metal, from which the electricity passes to complete the necessary closed circuit.

The earth is a reservoir of electricity: it is disturbed at Liverpool by the excitement of the voltaic influence, and its pulsations are communicated at once to London. The idea of any principle passing *along* the telegraph wires must be discarded. A current, as something flowing, conveys a false idea; but we have no other term to express electrical progression. Suppose the telegraph wire to be a tube filled with water, and that one drop more is forced into it at Liverpool, one drop will of course fall out in London. Something analogous to this occurs with electricity. In the experiments of Breguet, on the railway between Paris and Rouen, it was determined that the resistance in a circuit of forty miles of wire and forty miles of earth was one-half through the earth to what it was through the wire. Printing telegraphs are constructed upon the principle of causing the electricity to effect chemical decomposition instead of to move a needle. Many

compounds are very readily decomposed by voltaic electricity; therefore, a piece of paper is covered with such a composition, and when touched with the wire, the decomposition is effected. Paper covered with a mixture of iodide of potassium and starch is sometimes employed; the electricity decomposes the salt, and a purple iodide of starch is formed, and the letter or sign is printed in this new combination. In other cases paper is saturated with the ferro-prussiate of potash, and kept moist; the terminal wire being of iron, Prussian blue is formed over every point when contact is completed.

In Bakewell's Copying Machine (433), the message is written with a resinous composition upon a slip of tinfoil. A point traverses over the cylinder upon which this is rolled, being moved by an endless screw; a corresponding point moving at the same rate over a piece of prepared paper at the other point of the telegraphic line. The resin of the letters cuts off the connection with the battery, so that the electro-chemical decomposition is very regularly set up and checked, and signs corresponding to those on the tinfoil are readily formed at any distance.

Highton's patent electric telegraphs and apparatus (432), and the printing telegraph, adapted to one or two wires; another by which any one of 26 symbolical characters is printed by a single touch of a key should be examined.

Morse's arrangement of telegraph, worked by secondary power:—a telegraph for showing the letters of the alphabet instantly, by the touch of a single key; with a revolving pointer, and a revolving disc; also, a series of indicating and pointing telegraphs, worked by various descriptions of coils, and steel magnets, and by coils acting on soft iron—telegraphic alarums, worked by electro magnetism, excited in the metal nickle, and also by coils and magnets, and by coils and soft iron—lightning extractors, for extracting from the wires of a telegraph charges of atmospheric electricity—arrangements for telegraph posts, by means of which a great saving may be effected in the construction of electric telegraphs—specimens of wires for

a submarine telegraph, protected by means of a covering of wire cable, and other examples, are contributed by the Electric Telegraph Company.

These specimens of wire for a submarine telegraph are designed to overcome the action of breakers, which proved fatal to the telegraph across the Channel, than which nothing otherwise could be more successful: if the wires can be buried deep enough in the sands to place them below the breaker action, there would be no difficulty in communicating readily with the Continent.

Electric telegraphs admit of a great variety of mechanical arrangements, by which the modes of signalizing are modified. In all the electric current does the work; in some by deflecting the magnetic needle directly, and in others by inducing magnetism in soft iron, which force acts upon some clock-like arrangement, and thus, by a mechanical contrivance, gives the required signal. The instruments 422 and 429 are of this variety. They are described as follows:—

The various letters or numerals represented on the dial are made by the motions of either or both of the indicators; the number of the motions for each letter or numeral is defined by the figures on the centre of the dial, commencing at all times with the indicator on the side next the letter or numeral, and when both indicators are used, finishing with the opposite one. The helices are double and of a circular form, and the magnet is in the form of a ring or horseshoe, suspended in the centre of the helices, and is deflected either to the right or to the left, according to the direction of the current. The poles of the magnet being equidistant from the earth, the magnet is rendered astatic, and not affected by the terrestrial magnetism.

These magnets move parallel with the coils of wire and planes of electricity. The indicators not being magnets are perfectly free from vibration, and the indication is therefore distinct and certain.

The alarum bell, for calling the attention of the at-

tendant, being liberated by a motion similar to that of the telegraph, gives three distinct blows; and should it, by any chance, be liberated by a current of atmospheric electricity, the apparatus would not be deranged.

The deflector on the left of the instrument enables the current to be transferred from the telegraph to the bell, and *vice versâ;* and it can also be used in case of an instrument getting injured, to pass the current along the line, without stopping the communications at other stations; with this, one wire only is required to enable every station on a line of railway to communicate with the whole by means of one instrument only at each station.

By the use of an underground arrangement of conductors (as exhibited in combination), the cost in the first instance, with wire encased in lead, is very little more than posts with wires suspended in the air, and with wire, incased in gutta percha only, much less; while the cost of maintenance is reduced to a minimum, and the liability of interference from atmospheric influence altogether avoided.

Magnets. (Exhibitors 259, 428, 438, 439.)—In the collection (428) are exhibited a large permanent horse-shoe magnet, weighing 6½ cwt., a magneto-electric machine, illustrating the application of the electric current derived from magnets, to the purposes of electro-chemical decomposition, electro-metallurgy, &c. Patent electric telegraphs, worked by the magneto-electric current.

The received theory of magnetism is, that the attracting power of the bar of steel which we call a magnet, is due to the circulation of electric currents around the bar. It was discovered by Faraday that when a metallic mass is moved in proximity to the poles, a current is induced in it: upon this principle magneto-electric machines are constructed. The soft iron armature or keeper of the permanent magnet is fixed on an axle, which is made to revolve by some mechanical contrivance, so that a continued

and rapid reversal of its poles takes place. By this alone a magneto-electric disturbance is effected; but, for the purpose of accumulating the force, coils of copper wire are fixed on the armature, and every time they approach or leave the poles of the magnet in the course of rotation, an induced current passes through the wire, and the reversal being extremely rapid, though the current is only instantaneous, the result is what may be regarded as an uninterrupted stream of electricity.

The magneto-electric machine was first employed for telegraphic purposes by Professor Wheatstone. The battery is, however, usually preferred in this country.

The exhibitors 438 and 439 have magnets of much power made of cast iron, which are exceedingly cheaply made. Mr. Herder, of Plymouth, was, we believe, the first to exhibit any magnet of this description.

Electrotype.—Some specimens of electrotype are included in this class. This application of electricity will, however, be fully dealt with in connection with the electrotype and electro-plate shown in Class XXIII.

Electro-Magnetic Engines. (Exhibitors 85, 417, 420; Class V., 661.)—The power which may be induced in a bar of soft iron by passing an electric current around it is enormous. There does not, indeed, appear to be any limits, provided we increase the size of our apparatus, and the chemical intensity of the voltaic battery, to the extent to which it may be carried: hence the numerous attempts which have been made from time to time to apply electro-magnetism as a moving power.

The mode of proceeding is, essentially, to roll a large quantity of copper wire, clothed with silk or cotton, around a bar of soft iron. When the ends of this wire are connected with a voltaic battery, the bar becomes a powerful magnet, and continues so as long as the current circulates through the wire. The connection with the battery being broken, the magnetic power immediately ceases. It is easy to remove, at pleasure, all magnetic

influence from any substance which may be submitted to its action; since, the moment connection is broken with the battery, the current ceases to traverse the wires, and all magnetic attraction terminates. Electro-magnets have been constructed capable of sustaining many tons, and, from the enormous power thus obtained, it has been thought practicable by many to apply it for the purpose of moving machinery.

The editor having instituted a very extensive series of experiments, with a view of determining the question of the applicability of electro-magnetism as a motive power, embraces a small portion of space to point out the difficulties, if not impossibilities, which appear to prevent its use within the limits of a reasonable economy.

In the first place, the rate at which the power diminishes through space prevents our obtaining the full force of the magnets. This is shown in the following table:—

				Pounds.
The magnet with the armature in contact supports				220
”	”	$\frac{1}{250}$ of an inch distant		90·6
”	”	$\frac{1}{125}$	”	50·7
”	”	$\frac{1}{100}$	”	50·5
”	”	$\frac{1}{83}$	”	51·1
”	”	$\frac{1}{50}$	”	40·5

No machine could be constructed in which the moving parts can be brought nearer together than the $\frac{1}{50}$th of an inch—this distance being required to meet the expansion of the iron—yet the power lost is enormous.

The best form of magnetic engine which has yet been constructed, is that in which a certain number of electro-magnets have been set upon the periphery of a wheel, and another similar set upon a frame surrounding the wheel, with an adjustment by which the direction of the current, and consequently the poles of the magnets, can be regularly changed; for the point at which the current enters becomes a north pole, and the point of its exit a south pole. Others have been designed, in which one electro-magnet

has been made to work in a cylinder, which was also electro-magnetic. This is the character of Mr. Hjorth's exhibited in Class V. Page's celebrated American machine appears to be constructed on the principle of drawing a core of iron into a helix of clothed copper-wire. By the reciprocating action of these piston-like temporary magnets, a considerable extent of motion is obtained.

The second greatest difficulty to be overcome is, that, notwithstanding the loss of power with distance, a still greater loss takes place with motion. The moment any magnetic body is moved in front of either a permanent or an electro magnet, it loses power, and this loss increases very rapidly with the increase of velocity. This obstacle stopped the progress of the very extensive researches of Jacobi, after he had expended upwards of 30,000*l.*, granted him for his experiments by the liberality of the Russian government; and in the report made on Professor Page's engine, we find that with increase of speed its horse-power is constantly diminishing. By the most careful calculations deduced from my experiments, and from the results obtained by others, it has been determined that the economic difference between a steam and an electro-magnetic engine is as follows:—

A grain of coals, burnt in the boiler of a Cornish engine, lifted . . .	143 lbs. 1 foot high.
A grain of zinc consumed in a battery to move an electro-magnetic engine, lifted but	80 lbs. 1 foot high.
The cost of coals is per cwt. not more than	9*d.*
The cost of zinc per cwt. is above .	216*d.*

Therefore, the cost of working an electro-magnetic engine, to do an equal amount of duty as a steam-engine, will be more than fifty times greater than it, both being moved with the utmost regard to economy.

Telekouphonon. (419.)—This speaking-trumpet is an adaptation of gutta percha tubing to acoustic purposes. It is

found that sonorous vibrations are continued along the air, within a gutta percha tube, in a very remarkable manner. This is due in all probability to the absence of all undulation in the material of the tube itself.

The other articles included under this number show how many and important are the uses to which gutta percha can be applied.

PHOTOGRAPHY. (Exhibitors 220, 250, 291, 292, 294, 295, 296, 297, 299, 302, 303.)—This constitutes so well-marked and so interesting a group that the character of the productions exhibited will be considered in general, with but an incidental reference to details. Some specimens are also exhibited in the Fine Arts Court (298, 299), and in the Main Avenue with Ross's telescope.

Talbotypes and Daguerreotypes are alike *sun-drawn pictures*,—the former on paper, the latter on plates of silvered copper. These are the result of labours carried on simultaneously, though without previous concert, in France by M. Daguerre, and in England by Mr. Fox Talbot. The Daguerreotype has hitherto yielded to the Talbotype in the number and importance of its applications, though not in the beauty and delicacy of its effects. In this latter respect both are now on an equality: recent improvements in the materials used have left them fair and well-matched competitors.

These two *principal* divisions of photography are certainly among the most important applications of science made in our day, requiring for their development the nicest attention to the laws of optics, and a facility of mastering complex chemical manipulations seldom found; but the routine once determined and carefully followed, requires less skill and infinitely less labour than the, in general, unsatisfactory works of most amateur artists.

Before we describe the method pursued in obtaining photographic pictures, it will be instructive to learn by what steps and by whose hands these marvellous productions have come to us; and the more so, since there is a

misconception on these points on the part of some of our neighbours, if not among ourselves.

Among the six nations that exhibit the 700 photographs now in the Exhibition (and, by the way, six of the most advanced in civilization), there is one, ever laudably at the foremost post, that has, in its desire of extending its fame, forgotten what was commenced before it entered the field, no less than what has been done contemporaneously. Be it our task courteously to recall the facts, and, that we may not be tedious, briefly to interweave them with the description of the various processes.

The idea of substituting for the lens of the human eye and its sensitive nervous structure, the retina, an eye of glass and a chemical surface—an artificial retina of paper so sensitive as ultimately to become capable of receiving in less than the *millionth* part of a second, and retaining for ever, the picture of an illuminated object, belongs undoubtedly to Wedgwood and Sir Humphry Davy. They obtained (in 1802) with a lens, pictures on paper and white leather, gelatine in both instances being the medium in the one case, supported and aided by flax or cotton fibre; in the other, held together by the mechanical structure of the natural tissue. We have noticed this singular analogy for the purpose of remarking that it is our belief that the chief point at present to be studied is the construction from gelatine of an artificial fabric that shall have the good properties (without the defects) of the substances first employed by our illustrious countrymen.

The next name deserving our respect is that of Joseph Nicephore Niepce: after a long series of ingenious experiments, he succeeded in fixing on a metal plate coated with resin the images produced by a lens, and in making an engraving from it by a chemical process. This was a step, though his process was not practically of value, the time required to produce an image being several hours in good sunlight.

We are inclined to place Niepce at the head of a third

branch of the art so successfully carried out by M. Fizeau —that of photographic etching.

The three branches are perfectly distinct: the several products can never be mistaken for each other. Why then should there be any controversy? The history is clear. The first idea of photography, the art of using light (phos, φως), to draw (graphe γραφειν), with an optical instrument, belongs to Wedgwood.

The first to fix a resinous image on a metal plate, and subsequently to etch that image, was Niepce.

After his death, his fellow-labourer, Daguerre (who died in Paris on the 10th of July, in the 62nd year of his age), invented a totally new process, but still on a metal plate, more perfect than Niepce's, and obtained more rapidly, yet not fit for portraiture: this was in 1839. In 1840 our countryman, Mr. Goddard, accelerated the process, giving it the value it now possesses.

Since the days of Wedgwood, it will be seen, that the paper process stood still; at least we hear of no step, until Mr. Fox Talbot, on the announcement of Daguerre's invention, at once sent to the Royal Society an account of his method of obtaining images in the camera obscura on paper and then fixing them; and this before the publication of Daguerre's process. To speak with the accuracy that history requires, Mr. Talbot's process was certainly known to the public six months before the Daguerreotype was published.

It is then incontestable that photography (used as a generic term) had its origin in England.

1st. That photography on paper, in all its varieties, was not only invented but perfected in England.

2nd. That photographic etching (a beautiful art) was invented in France by Niepce, and perfected in France.

3rd. The production on a metal plate of a latent positive image to be developed by mercurial or other vapour.

The Daguerreotype is due to France, though its perfection was accomplished in England.

The production of colours on a chemical tablet was also first noticed in England by Sir J. Herschel on a vegetable juice, and Mr. Hunt on fluorine. This has been carried further in France, but remains imperfect.

We therefore claim the greatest amount of credit for our own nation, whether justly or not our readers must determine; always remembering that published evidence can be produced on our side. In the history of inventions, friendly narratives and hearsay statements, especially at variance with published memoirs, cannot be admitted, except under peculiar circumstances excluded by the present case.

Daguerrotypes.—These pictures are obtained upon a silver surface: copperplated with silver by the Sheffield process is usually employed. This plate being well polished, is exposed to produce the utmost degree of sensibility to the mixed vapours of iodine and bromine (substances described in Class II.). By this exposure, the silver becomes coloured, and a very delicate coating of a bromo-iodide of silver is obtained. It is now placed in the camera-obscura, and this instrument being adjusted, the image which falls on the prepared plate effects a chemical change; which is in the exact proportion to the intensity of the radiations from the particular parts of the object to be copied. The impressed image is not visible: to develop it, the plate is placed over mercury, slightly warmed, and the metallic vapour is condensed on the surface in very exact relation to the amount of chemical change. The picture which exhibits such infinite delicacy of outline, and minuteness of detail, results, therefore, from the contrast between the pulverulent deposit of mercury, and the polished silver plate. These photographs are rendered permanent against the further action of the sun's rays, by washing with the hyposulphite of soda, and against the operation of time, by the following process of M. Fizeau, to whom photography is much indebted:—

"Dissolve eight grains of chloride of gold in sixteen ounces of water, and thirty-two grains of hyposulphite of soda in four ounces of water; pour the solution of gold into that of the soda, a little by little, agitating between each addition. The mixture, at first slightly yellow, becomes afterwards perfectly limpid. This liquid now contains a double hyposulphite of soda and gold.

"To use this salt of gold, the surface of the plate should be perfectly free from any foreign substance, especially dust; consequently it ought to be washed, with some precautions which might be neglected if it was to be finished by the ordinary mode of washing.

"The following manner generally succeeds the best: the plate being yet iodized, and perfectly free from grease on its two surfaces and sides, should have some drops of alcohol poured on the iodized surface; when the alcohol has wetted all the surface, plunge the plate into a basin of water, and after that into a solution of hyposulphite of soda.

"This solution ought to be changed for each experiment, and to consist of about one part of the salt to fifteen of the water: the rest of the washing is done in the ordinary way, only taking care that the water should be as free as possible from dust.

"The use of the alcohol is simply to make the water adhere perfectly all over the surface of the plate, and prevent it from quitting the sides at each separate immersion, which would infallbly produce stains.

"When a picture has been washed, with these precautions, the treatment with the salt of gold is very simple. It is sufficient to place the plate on a support, and pour upon its surface a sufficient quantity of the salt of gold that it may be entirely covered, and heat it with a strong spirit-lamp; the picture will be seen to brighten, and become, in a minute or two, of great force. When this effect is produced, the liquid should be poured off, and the plate washed and dried."

The coloured Daguerrotypes exhibited are all the result of subsequent paintings by hand. This has been brought to a considerable degree of perfection; but it has nothing whatever to do with the process of sun-drawing. Popular taste appears to be in favour of those coloured portraits; but it appears to us, that all the extreme delicacy and beauty of Daguerrotype is sacrificed to obtain a very questionable advantage. The enamelled Daguerreotypes (292) have no photographic peculiarity—every step of the process is of a similar character to that described, and, the picture being finished, a resinous preparation is floated over it by the agency of heat. By this the picture is preserved against any injury from rubbing, or any mechanical violence of that kind. Upon the use of varnishes, Daguerre wrote in 1839:—"The author made attempts to preserve his sketches by means of different varnishes obtained from succinum, copal, India-rubber, wax and various resins; but he has observed, that, by the application of any varnish whatsoever, the lights were considerably weakened, and at the same time the deeper tones were hidden. To this disadvantage was added the still greater injury from the decomposition of the mercury by the varnishes tried."

The *Talbotype*, or as it was called the *Calotype*, process is on paper. Mr. Talbot's description of his process, the patent for which is dated 1842, is as follows:—Take a sheet of the best writing-paper, having a smooth surface, and a close and even texture. The water-mark, if any, should be cut off, lest it should injure the appearance of the picture. Dissolve 100 grains of crystallized nitrate of silver in six ounces of distilled water. Wash the paper with this solution with a soft brush on one side, and put a mark on that side, whereby to know it again. Dry the paper cautiously at a distance from the fire, or else let it dry spontaneously in a dark room. When dry, or nearly so, dip it into a solution of iodide of potassium, containing 500 grains of that salt dissolved in one pint of water, and

let it stay two or three minutes in the solution. Then dip the paper into a vessel of water, dry it lightly with blotting-paper, and finish drying it at a fire, which will not injure it even if held pretty near; or else it may be left to dry spontaneously. All this is best done in the evening by candle-light: the paper, so far prepared, is called *iodized paper*, because it has a uniform pale-yellow coating of iodide of silver. It is scarcely sensitive to light, but nevertheless it ought to be kept in a portfolio or drawer until wanted for use. It may be kept for any length of time without spoiling or undergoing any change, if protected from sunshine. When the paper is required for use, take a sheet of it, and wash it with a liquid prepared in the following manner:—Dissolve 100 grains of crystallized nitrate of silver in two ounces of distilled water; add to this solution one-sixth of its volume of strong acetic acid. Let this be called mixture A. Make a saturated solution of crystallized gallic acid in cold distilled water. The quantity dissolved is very small. Call this solution B. Mix together the liquids A and B in equal volumes, but only a small quantity of them at a time, because the mixture does not keep long without spoiling. This mixture Mr. Talbot calls the *gallo-nitrate of silver*. This solution must be washed over the iodized paper on the side marked, and, being allowed to remain upon it for half a minute, it must be dipped into water and then lightly dried with blotting-paper. This operation in particular requires the total exclusion of daylight; and although the paper thus prepared has been found to keep for two or three months, it is advisable to use it within a few hours, as it is often rendered useless by spontaneous change in the dark.

Paper thus prepared is exquisitely sensitive to light; an exposure of less than a second to diffused daylight being quite sufficient to set up the process of change. If a piece of this paper is partly covered, and the other exposed to daylight for the briefest possible period of

time—a very decided change is produced, which is indicated by the very rapid alteration of colour produced upon the application of a second wash of the gallo-nitrate of silver.

The paper being placed in the camera, and the image of any external object impressed, nothing more is necessary for its full development than to remove it into an artificially, and dimly-illuminated room, and wash it over with the solution of the gallo-nitrate of silver. When the picture has reached the intensity required, the paper is first soaked in water, and afterwards with a solution of hyposulphite of soda, to remove the sensitive coating, and render it permanent. The image thus obtained is a negative one, that is, the lights and shadows are the reverse of those in nature: to obtain positive or correct pictures, a second copy must be taken from the original negative.

Photographs at present require the assistance of art.

An artist discerns many defects—prominent features are often flattened by too much light, distant parts are sometimes brought too much forward, and harsh lines produced from too much vertical light.

The photographer's glass-house must be brought to give effects more in harmony with the artist's studio, the light must be more concentrated, and a system of reflected lights studied to meet the requirements of the art. These points are not sufficiently attended to in this country.

The defects are the want of half tints often, and aerial perspective imperfect; the shadows too black, and lights too strong, or scattered like snow. This is not always so, and the reason of its occasional occurrence wants investigation.

In still life very dilute solutions deserve trying, rather than strong ones—at least so our experience inclines us to; and the examples (250) show the advantages of employing a longer time than ordinary for subjects of still life.

Small apertures should be used to get definition, and longer focus lenses for the large plates.

Many photographers sin against both these rules. *Some* profess to like an indistinct hazy picture as being artistic; we think they are wrong.

Positives, made on albumined paper, are finer than those obtained on ordinary paper, giving more half tint and definition in the shadows.

The colour of positive pictures may be altered by using decomposing hyposulphite of soda, either by long use or by adding acid to it.

Mr. Malone, to whom photography is much indebted, has shown that caustic potash gives a warm bistre colour, and fixes the photograph more securely by removing sulphur left in the paper in the fixing process. The picture shrinks in the operation, but the negatives so treated become finer.

Did space allow, we should be induced to dwell upon many of the phenomena of photographic action; but we may simply state that it is now rendered certain, from the careful investigations of experimentalists, that the luminous agency of the sun's rays is not the agent producing those pictures, but they are due to the action of a peculiar agency to which the name of *actinism* has been given, associated with heat and light in the solar beam.

Photographs on Glass Plates are obtained as follows:—

In the *Technologiste* for 1848, M. Niepce de Saint Victor published his mode of applying albumen to glass plates. M. Blanquart Everard followed: and successively albumen, gelatine, serum, collodion, and other substances, have been recommended for application on glass; but few of these substances have been found to answer so perfectly as albumen applied according to the directions of M. Le Gray.

He recommends that the whites of fresh eggs, equal to about five fluid ounces, be mixed with not more than 100 grains of iodide of potassium, and about 20 grains of the bromide, and half that quantity of common salt.

He then directs you to beat this mixture in a large dish with a wooden fork until it is reduced to a thick white froth, to let it repose all night, and the next day to decant

the viscous liquid which has been deposited, and use it for the preparation of your glasses.

For this purpose take thin glass, or, what is much better, *ground glass, on which the adherence is more perfect*, cut it the size of your camera frame, and grind the edges.

The success of the proof is, in a great measure, due to the evenness of the coat of albumen.

To obtain this, place one of your glasses horizontally, the unpolished side above (if you use ground glass, which is thought preferable), and then pour on it an abundant quantity of the albumen. Take a rule of glass very straight, upon the ends of which have been fastened two bands of stout paper steeped in white wax ; hold this with the fingers in such a manner that they will overlap the sides of the glass plate about one-eighth of an inch. You then draw the rule over the glass with one sweep, so as to take off the excess of albumen. The object of the slip of paper is to keep the glass rule from the surface of the plate, and insure a thin but even coating of the albuminous mixture.

The plates being thus prepared and dried, are preserved for use. When required, a solution of nitrate of silver is applied, and if sensibility is required, some gallic acid is added, and the picture developed in the ordinary manner. The copies in the Fine Arts Department are from negatives on glass plates.

Collodion, which is gun cotton dissolved in ether, is applied in a similar matter, mixed with iodide of silver. This substance, mixed with iodide of silver, possesses very high sensibility, portraits being obtained in a few seconds.

By a modification of known processes, and the introduction of a new element, Mr. Fox Talbot has produced a surface so sensitive that an image placed upon a rapidly-revolving wheel, illuminated for an instant only by the electric spark, was impressed, without any distortion, upon his prepared glass plate, the operation being absolutely instantaneous.

Amongst the applications of the art, we may mention its value to artists in securing sketches and hints from nature for producing copies of their works as souvenirs, and to the draughtsman for copying manufacturers' patterns and machines, some of which have been used in the Official Illustrated Catalogue.

Botanical specimens may be beautifully copied; the leaves give every vein most perfectly, and microscopic views of sections are exceedingly faithful.

Specimens exhibited show its value to geology, rocks being copied with every joint and cleavage plane distinctly indicated.

Architecture is most truthfully given, and a mathematical correctness is obtained; for the size of the image, the length of the focus, and the distance from the object, being known, the height is at once obtained by a simple rule-of-three sum.

The French Government Committee of Historical Monuments has employed several photographers to take old cathedrals, &c., in France, thus encouraging the art; and travellers have been furnished with the apparatus necessary.

At Lyons a society exists which pays for microscopic photographs of silk fibre, some of the plates of which are in the Exhibition.

Observatories have Ronalds and Brooke's apparatus; and the British Museum has sent out a camera to Layard, from whom we may expect to receive faithful representations of the remains of Nineveh which cannot be removed. Such is the importance of an art which may be regarded as even now in its infancy.

The Photographic Camera Obscura. (Exhibitors 220, 250, 254, 263, 265, 996.)—The camera obscura is the invention of Baptista Porta. In its most simple form it consists merely of a dark chamber, with a small hole through which the light is admitted. The luminous rays from the images externally to this passing through the hole produce

an inverted picture of the objects; if a lens is placed in the hole, the lenticular image formed in the focus of the lens is exceedingly vivid and beautiful; and if this is allowed to fall upon properly prepared surfaces, a very pleasing picture results.

In 265 we have a very portable instrument of this kind, the novelty consisting in its having a flexible cloth body, and the whole so constructed as to admit of being packed into a very small space. The appendages necessary for practising the art are all equally well and conveniently adjusted.

Another portable camera will be found (220), consisting of a folding instrument for taking Talbotype, and other photographic pictures, on paper, of the size 9 inches by 8 inches. The body of the camera folds up into a space less than 1 inch in thickness. The front of the camera, by means of a slide adjustment, allows the compound lens to be shifted with relation to the centre of the camera for the purpose of altering the relative proportion of foreground or sky in the required picture. The frame is capable of holding two sheets of prepared paper in the space usually occupied by one. The frame opens in the centre between two plates of glass, which are attached to and closely pressed together by the two portions of the frame when close, and the prepared sheets of paper are placed back to back between the two glasses, and thus kept out of contact with the air, and are alternately exposed in the camera by merely reversing the frame. The compound achromatic lens can be separated into two portions, so as to form either a long or short focus lens. When the two lenses are employed, the frame holding the prepared paper is placed in the centre of the camera, the top of which is hinged for the purpose; and when the single or long focus is used, the frame is placed at the back of the camera in its proper groove.

A New Portable Camera Obscura.—In the optical arrangement of this instrument, a meniscus lenticular prism is

employed, by which a very vivid and flat picture is obtained; when closed, the size of the box is 15 inches long, 9 inches wide, and about 3½ inches deep.

Instruments for Determining Variations of Actinic Power. (296.)

The Photographometer is a very ingenious instrument for determining the amount of chemical agency in the solar rays at any given time, and for ascertaining relatively the sensibility of any preparation. The sensitive plate or paper is placed in a dark box, pierced with holes, which is fixed in an independent frame. A moveable plate with vertical openings is adjusted to pass at any required speed over this, so that the plate may be exposed for any known time to the solar radiations: thus is ascertained by the change induced, either the relative sensitiveness of the preparation, or the quantity of chemical power in the sun's rays at any given time.

The Focimeter, by the same exhibitor, is a very simple plan for focusing. This is merely segments of a circle, numbered and placed at fixed distances apart, upon a moveable axis. This is copied by the camera on a plate or paper, and the result seen is different degrees of effect produced.

The Dynactinometer (296) is thus described by the inventor.—It consists of a thin metallic disc, perfectly black, having a slit extending from its centre to the circumference, fixed on an axis revolving through a fixed metallic disc, perfectly white. The white disc has also a slit from its centre of the exact length of the radius of the black disc; and by means of these two slits, and of their spiral surfaces, the black disc can intersect the white disc, and, by revolving, gradually cover the whole white area. The space of the white surface on which the black disc can be superposed, forms itself a sort of dial, which is divided into any number of equal segments, all numbered. I have adopted the number of twenty segments for a large circle inscribed on the dial, and of eight segments for a

smaller circle inscribed in the first. The first twenty segments are numbered in simple arithmetical progression, and the eight segments in geometrical progression 1, 2, 4, 8, 16, 32, 64. The object of these two kinds of progression will presently be explained, but the second is more appropriate to the object in view.

The black disc may be made to revolve in such a manner that it shall cover a new segment of the large circle during each second, or any other equal fraction of time. By that means the last segment will have received twenty times more light than the first, and all the others in arithmetical progression.

The instrument is made to move by applying the hand to a handle fixed on the back at the extremity of the axis on which the disc revolves. An operator accustomed to count seconds by memory, or by following a seconds' beater, can perform the experiment with sufficient regularity; but in order to render the instrument more exact and more complete, it can be made to revolve by clock-work, which gives it at will either the arithmetical or the geometrical progression. This last movement presented some difficulty; but I have been able to obtain it without much complication in the machinery, and the apparatus is within the reach of the greater number of operatives having establishments on a complete footing.

For the instrument moving by hand, it is necessary that a second person should open and shut the object-glass at a given signal; but in adapting before the object-glass a flap connected with a cord and pulley, the operator, holding the cord in the left hand, can open the flap at the moment that, with the right hand, he makes the disc revolve, and shut the apparatus when the revolution is complete.

When the instrument acts by clock-work, the object-glass may be opened and shut by the same means at the signal given by a bell which strikes at the commencement and at the end of the revolution.

It will be now understood how this is made available to

many important purposes for determining photographic phenomena. In the same collection will be found some very interesting illustrations, showing how the luminous and chemical power (*light and actinism*) of the sun's rays may be separated from each other.

Photographic Self-acting and Registering Magnetic and Meteorological Apparatus. (144.)—The variations of a magnet hung free to move are of a very remarkable character, and promise to lead to some important knowledge connected with the phenomena of terrestrial magnetism. The importance of making these instruments, which are employed to measure magnetic forces, self-registering is exceedingly great; and the instrument exhibited is to effect this. Essentially it consists of a mirror placed on the end of a magnet, which reflects a concentrated pencil of light upon some highly-sensitive photographic paper, placed between two glass cylinders: these move the paper vertically while the magnet moves horizontally, therefore every vibration of the needle is most distinctly marked. In the same way a piece of photographic paper, being moved behind the mercury of a barometer or thermometer, is impressed by the solar rays as they pass above the column, and consequently, as this alters, the impression varies, and every movement is indicated. The combination of these instruments, and the mode of registration, are deserving of careful attention.

Gymnastic Pedestal. (570.)—This simple apparatus contains, in the smallest compass, viz., 6¼ inches square, by 4 feet high, six different exercises, calculated to bring into action either the whole muscular system, or, separately, any part of the body which may be deficient in strength. Its size, portability, and the facility it affords of being fixed in any place, however small it may be, will make it a most desirable acquisition for every family, as being useful not only for children, but also for adults, whose sedentary avocations require to have at hand some ready means of stimulating the vital functions, and keeping up muscular energy, by physical exercises.

Chemical Apparatus, Tests, &c. (Exhibitors 453, 457.)—The chemical apparatus exhibited (457), and which, though it extends to all the branches of experimental chemistry, and to most of its applications in the arts, is confined to one small glass case, is characterised by one property—that of showing the greatest amount of chemical power in the smallest compass. By the use of apparatus made of the best materials, and of the most effective forms, chemical power is economised. But in proportion to the excellency of chemical apparatus, the less is it calculated to strike the eye of the general observer. There is, for example, among the articles in this glass case, a small box of instruments, which consists of a lamp furnace and a few glass vessels, but the power of which is said to be, to add 20 per cent. to the productiveness of a sugar estate in the West Indies, without any increase of expenditure. This is effected by applying chemistry to regulate the mixing of lime with cane-juice in one of the early stages of the sugar manufacture.

Apparatus for use in colonial sugar-works, in determining the density of cane-juice, and the exact amount of lime required for properly clarifying the juice. Invented by Dr. Shier, agricultural chemist to the colony of British Guiana.

This application of the art of chemical testing to the preparation of sugar is important. The expressed juice of the sugar-cane rapidly decomposes. To prevent this, quicklime is added to the juice to clarify it. Generally it is added by guess, the planters having no sure guide to show how much lime a given quantity of cane-juice requires. Dr. Shier, by a series of experiments performed at Demarara, has solved this difficulty. He tests four ounces by measure of any cane-juice with lime-water, applied by a centigrade test tube, and determines thence the quantity of lime required for any larger quantity, say for 500 gallons. The benefit is enormous: 20 per cent. of sugar is saved, which, on the old plan, is destroyed or con-

verted into molasses. As the process is easy as well as certain, it is of great importance to all engaged in the manufacture of sugar. So large an increase in product, without any increase in expenditure, puts in a striking point of view the importance of chemical knowledge in the arts.

Apparatus for Centigrade Testing, or for Chemical Testing, in the Arts.—The method of chemical analysis by measured test liquors has not till recently been in much esteem, from the difficulty of obtaining accurately-graduated measures, and from want of a general system applicable to such a mode of testing, viz., the want of a method of preparing the test liquors and reducing the results of experiments on one uniform plan. Mr. Griffin's system of equivalent test liquors affords a ready method of preparing chemical solutions of well-ascertained degrees of strength, by means of which common workmen, engaged in chemical operations, can perform analytical processes with perfect accuracy, provided, always, the use of such test liquors be accompanied by the use of glass measures graduated with perfect accuracy.

There are numerous other examples of chemical appliances, well deserving the attention of all experimentalists.

The Chemical Cabinet (453) may be regarded as one of the most complete and ingenious ever made, uniting within itself all the conveniences of a well-furnished laboratory. In immediate connection with this, and from the same exhibitors, will be found several pieces of philosophical apparatus of a superior description, and also some arrangement for aiding photographic manipulation, which are of the utmost importance.

Musical Instruments.

Position of Class.—*In Central North Gallery, from Pillar* I. 18 *to* I. 22, *and on the space connecting the North Galleries, Pillars* I., 18 *and* 19.

Organs, Concertinas, &c. (Exhibitors 526, 528, 529, 544, 545, 548, 553, 554, 555, 557, 559, 562, 735.)—Musical instruments of this class are well displayed. The study of them

will make the visiter well acquainted with all the varieties. 559 is the enharmonic organ, presenting the power of executing with the simple ratios in 20 keys, and having a correction for change of temperature, invented by Col. T. Perronet Thompson. The object of this instrument is, first, to determine the proportions which make music in a single key, and then to transfer the same proportions to a variety of keys, beginning from some of the previously-established sounds as a new key-note. The same process was attempted by the ancients, constituting what they called the enharmonic scale, but broke down, and was finally abandoned, in consequence of making an unfortunate division for a single key. The leading principle involved in this instrument is, that the dissonances are double, or have each two forms, one of which makes harmonious combinations with the fifth of the key and the thirds, and the other with the fourths and the sixths. In pursuance of this principle, if the red manual is taken for the key-note (that is to say, C on the lowest board, E on the middle, and D on the upper), the thirds and fifths of the key will be found coloured white, and the fourths and sixths black, the acute forms of the dissonances being also white, and the grave black; so that the similarity of colours helps to point out the connection of the sounds. After this it was an easy observation, that a few more manuals in the positions of those resembling the keys of a flute, would give the power of executing in the various additional keys marked on the oval scutcheons in front of the respective finger-boards. The manuals resembling a gilt-headed nail present E♯, B♯, F×; to provide G♭, or C♭, one of the exchangeable pipes must be inserted in the place of F♯, or B♯, on the lowest board.

On the whole, the number of keys amounts to 20, extending from eight sharps (or, as generally called, six sharps and a double sharp) to six flats. In many cases there are keys for the two forms of the same note, which may be used according to circumstances.

The tuning is effected by means of what is called a phonometer, being a monochord with a wire of 4 feet, stretched by a weight capable of very accurate adjustment. The compass is what is called the German scale, or from CC to F in alto. The pipes are of wood, of that order called stopped diapason, and each is tuned with a screw; the whole number being 155, besides those which may be denominated exchangeable: the swell is divided in two at middle c', and each part has a quick and a slow movement. The dimensions of the instrument are, in extreme height, 8 feet 5¼ inches; length, 7 feet 5 inches; depth, 3 feet 7 inches; being less than the dimensions of a grand piano, except in height.

562 is a model of a transposing organ; the transposing power does not move either the keys or pedals, yet acts upon them simultaneously. The extent is five semitones, higher or lower, from a given scale.

A series of barrel organs, built on a peculiar construction, and adapted to the service and dimensions of any church, are exhibited (735); from their simplicity of construction and arrangement, and the facility with which the tunes can be changed, these instruments are recommended.

The 'Autophon' is a name given to an instrument said to be an improvement on the barrel-organ, the tunes, which are unlimited, being produced by perforated sheets of millboard, which are placed in an aperture in the front of the instrument, and upon the performer's turning a handle, are drawn in. The wind passing through the holes in the millboard produces the tune, by which means a person unskilled in the art of music is enabled to perform the most finished compositions.

A grand church organ, of the first class (at the east end of the United States Gallery), and a small church finger organ, (North Transept Gallery, 555,) the stops of which are contained in a swell with Bourdon pedal pipes, independent of the manual; it plays any number of tunes without shifting the barrels.

The peculiarity of the small choir organ (557) is a stop called the diaocton, which makes every single stop as good as two distinct ones, having, therefore, double the power and variety of an ordinary organ. The choir organ, properly so called, is that part of a large organ which is used for accompanying the choir of singers in a church or cathedral, and is softer voiced than the rest of the instrument.

A treble concertina (526), with 48 keys, for the performance of violin, flute, hautboy, or concertina music, singly or in concert, is ingenious; it displays the whole of its internal mechanism. A portable harmonium, for producing expression, which can be played alone, or placed in front of the key-board of the piano, and played by the same performer.

528 is a seraphine, with bichromatic or double scale of notes, said to produce perfect harmony in every key.

The percussion œolophon (529), with two sets of vibrators, one an octave higher than the other, with appropriate stops, is intended as an economic substitute for an organ.

The concertinas (544), in ivory, with gold stops, working on levers supported by springs, are exceedingly sweet instruments. The concertina, however, in its present state, can never compete with the violin and similar instruments, as it is deficient in forgando effect.

545 is another concertina, on which may be played any description of music within the compass of three octaves and a half, in single notes or chords.

Organ metal pipes (548), are exhibited in plain and spotted metal. The best metal for organ pipes is pure tin, by reason of its sonorous character: this metal, however, being expensive, is frequently mixed largely with pewter.

Pianos. (Exhibitors 168, 464A, 467, 468, 469, 470, 471, 472, 474, 475, 476, 477, 477A, 479, 480, 481, 482, 484, 486, 487, 488, 489, 490, 491, 492, 493A, 494, 495, 496, 498, 499, 500, 516, 518, 550, 683.)—The origin of the pianoforte may

be traced back to the beginning of the last century, although there have existed for the last three or four hundred years, stringed instruments which, under the names of clavichord or manichord, virginal, spinet, and harpsichord, may be said to have originated the pianoforte.

The name of the actual originator of the instrument is, however, lost amidst a crowd of claimants. Some attribute its origin to a Florentine, named Domenico Cristofali, in 1711; others accord the merit to a Bohemian, named Schroeter, in 1717; while others again ascribe it to an English monk, resident at Rome, named Padre Wood, who is reported to have made the first pianoforte ever seen in England, for his friend Mr. Chrisp, who subsequently sold it to Mr. Fulke Greville, for one hundred guineas. Another authority awards the merit to Mason, the poet, author of "Caractacus." Father Wood's pianoforte was reported to be of a superior tone to that produced by quills, with the additional power of producing all the shades of *piano* and *forte* (whence the name of the instrument); that though the touch and mechanism were imperfect, yet solemn and pathetic strains, executed upon it with taste and feeling by a master little accustomed to the touch, excited equal wonder and delight. Schroeter's instrument, had hammers covered with leather, which recoiled after having struck the strings. In 1766, Buckers and Zümpe, who were contemporary, first established themselves in this country as manufacturers. The first patent granted for pianos bears date 1777; it is, therefore, not more than three quarters of a century since the manufacture of that instrument began to attain a degree of extension sufficiently considerable to warrant the expense of patents.

This patent was "for a piano with an octave swell." The specification gave the mechanical means of uniting the octave stop of the harpsichord with the grand piano. The action of that sort of pianoforte called the grand ac-

tion is drawn complete in the specification, without a claim being made to it as part of the invention. It may, therefore, be inferred that as early as 1777 the grand action, or the common action for grand pianofortes, was in general use. Nothing was done towards improvements in that action until Erard's repetition action was patented in 1821.

At the end of the last century, the attention of musical instrument makers was almost exclusively directed to the problem of combining on one set of keys several sorts of instruments, in order to produce new musical effects. In 1790 a new instrument was specified, which united with the pianoforte a set of pipes to imitate the German flute, and another contrivance to imitate the harp. These three sorts of tones were played, either together or separately, by means of pedals.

The grand piano at the outset differed very little in its construction from the harpsichord. The mechanism of the harpsichord consisted simply of a finger-key, upon which stood an upright piece of wood, technically called a jack, with a piece of quill fixed into it for the purpose of putting the string in vibration. The jack was also provided with a piece of cloth, placed above the quill, intended to act as a damper on the string, and stop the vibration as soon as the finger was raised from it. In the pianoforte, instead of the jack, a similar contrivance, technically called "the old man's head," is raised by the motion of the finger-key, a hammer moving on a centre towards the string. This new mechanism enabled the player to strike the wires either forte or piano, whilst in the harpsichord the unvaried mode of putting the string in vibration could never produce anything but the same monotonous intensity of tone.

464A is a pianoforte with peculiar action, accompanied by a model of the same, showing that the improvement consists in the reduction of the number of the parts into which the lever attached to the hammer is divided. This

will be appreciated when compared with a model of the common method which is placed alongside of it.

There is considerable ingenuity in an expanding and collapsing pianoforte (484), for gentlemen's yachts, ladies' cabins, saloons of steam-vessels, &c., which measures only 13½ inches from front to back when collapsed.

The harmonium (477) is an instrument played like the pianoforte, combining the variety of instruments, with great power of tone, and durability in all climates. The peculiar tone of the harmonium class of instruments is produced by metal springs set in motion by a stream of air.

Propeller action piano (495). This action being chiefly metallic, is reduced to about one-fifteenth the amount of material in bulk usually employed, thus removing a mass of stuff before the strings, which otherwise prevents the flow of tone; it also reduces the amount of atmospheric influence and friction by the extreme simplicity of its mechanism. It is warranted by the exhibitor to remain a longer time in order than those in general use.

The grand piano (168), in British mottled oak, with gold decorations in the style of Louis Quinze (Main Avenue West), will be admired by many.

The bichord piano, grand cabinet piano, all with the patent check and repeater action, and the pianoforte for the people, are peculiar. In reference to these instruments we quote the following valuable remarks:—

The progress of popular taste, in all matters of intellectual refinement, demands fostering encouragement wherever it is met with; and it is a subject for congratulation to find the people appreciating good Art, or pure mental enjoyments, when offered to them at a reasonable rate. To no branch of the Fine Arts can improvements be limited, and the spread of taste among the humbler classes must ever be regarded as the most humanising of all good gifts. With a keen relish for music amongst them, which is now rarely realised but by listening to the abor-

tive attempts of an itinerant fiddler or organ-player, how much more might this taste be indulged could it be gratified in a higher manner; and what good might result from the superior feeling which the love for such study would, of necessity, foster and increase? In November, last year, a writer in that widely-spread and justly-esteemed periodical, *Chambers' Edinburgh Journal*, enforced these opinions strongly, saying:—"It is in this point of view that music should be regarded by philanthropists: the science should be given to the masses of the people as a bond of sympathy between them and the upper stratum of society. But while many efforts are making in this direction, there is still great sluggishness in one important branch of the business: the lower classes have no good instruments, and have no great artists. The comparatively poor and the really economical do not buy pianos, simply because they are far beyond their means: and in England the cause of musical science and kindly feeling is deprived of the aid of a family instrument, which in Germany is found even in the parlour of the village public-houses."

It has remained for the Exhibitors to remove this objection, by the manufacture of instruments, which are in no degree inferior to the best in tone and touch, but greatly so in price. This economy has been effected by bestowing as much thought and labour on the interior construction of the instrument as usual, but adopting a plainer kind of case, constructed of cheaper wood, that of the Norwegian pine, and which, we believe, has never before been used for such a purpose. It is remarkably white, and when French polished, rivals the more expensive satinwood, in the purity and delicacy of its effect. The same amount of simplicity is visible throughout the piano. It has the full compass of six and three-quarter octaves, the improved single action, and all the advantages of construction usually adopted.

Connected with the 7-octave, full grand pianoforte with repetition action in rosewood case—the fonda semi-grand

pianoforte in walnut case—oblique piccolo pianoforte—is the miniature model of a grand pianoforte, 6¾-octaves with metal braces and drilled bridges. This little instrument, designed to illustrate the effect of the modern improvements in pianofortes, is the smallest, to be played upon, ever made. It has the full compass of 6¾-octaves from C to G, and is on the upbearing principle throughout. It appears to possess all the modern improvements, and to be complete in every department; fulness and clearness of tone, power and promptness of the mechanism, elasticity of touch, and close damping with the movement of the pedals, the manufacturers are not without hope that it may be the means of suggesting improvements to render the grand piano a still more perfect instrument, by showing that the size may be lessened without a corresponding reduction in the amount of tone, and that were the present key-board contracted a little, what fine effects and extended harmonies would be placed within the reach of the pianist!

A few years back it would have been deemed totally impossible to make so small an instrument with the full compass of keys, to produce any effect; but the modern additions of metal string-plate and bracings, drilled metal bridges, and the generally improved method of construction, &c., &c., has enabled it to be done; while the large amount of tone, considering the string is only twenty-four inches long, procured in the lower notes, is produced by a treble-spun string, composed of steel, soft iron, and copper wire, which is made by the aid of a machine recently invented.

683 is a cottage pianoforte, with repeating check action, new tubular supporters, ivory and tortoiseshell keys; and 468, a semi-grand pianoforte, constructed on the principle of the speaking trumpet, with unison tuning screws, and repeating tongue check-action—ivory is replaced by a newly-invented material for the keys.

In 471, we have a grand pianoforte in rosewood, on the

exhibitors' new patent suspension principle. The sounding-board instead of being glued, or permanently attached to the wooden framing, is suspended from it by metallic attachments, which being adjustable, admit of its being tightly strained to increase the tone: an upright cottage pianoforte, showing the application of the same principle to the cheaper kind of pianos. 472 is a patent self-performing pianoforte, combining many of the advantages of an instrument of the usual construction, and many facilities to those unacquainted with music. The notes being adjusted on boards, are moved over the instrument, and by a peculiar arrangement the tones are regularly and correctly struck.

The long brass joint, generally seen upon the fall of pianos, is obviated in 474 by a simple contrivance.

In the registered tavola pianoforte, 477A, a dining or drawing room table stands upon a centre block or pedestal, and contains the instrument, which opens with spring-bolts, on the grand principle; with a closet containing music. This pianoforte has the ordinary power of tone, although occupying half the usual space, and can be made the piccolo or grand size. The combination of the table and piano has been effected before;—twenty years ago, Mr. Ray, of Edinburgh, made instruments that presented this novel construction.

In 480—walnut wood registered cottage pianoforte—the keys of the finger-board are alternated in colour to show all the scales, major and minor, according to a single rule for each mood, founded on the plan of the semitone interval, which renders the seven notes to be touched for an octave of each of the other eleven scales. Three keys of one colour taken consecutively, and four of the other, form any scale in the major mood; and two keys of one colour, and five of the other, taken consecutively, form any scale in the minor mood. This piano is entirely for the purpose of tuition.

481 is a double, or twin semi-cottage pianoforte, having

two fronts or sets of keys, one on either side suitable for any number of performers, from one to six.

And 486, the lyre, a cottage pianoforte, in the form of a lyre, with long scale, and a peculiarly-constructed platform, whereby the performer or vocalist is enabled to face the audience.

A Transposing Pianoforte. (487.)—This piano is said to transpose music five semitones higher or lower than the written key if necessary. Its novelty consists in the keyboard, hammers, and strings being immoveable: the internal action cannot be shifted or deranged.

The registered compensation pianoforte (489), seven octaves, has some peculiar mechanism, which by its lightness, &c., is said to produce an agreeable touch; and in 490 we have a pianoforte with new improvement. It has a bevel action for the dampers (applicable to all kinds), intended to give precision of touch by the certain rising of the key; it preserves also the dampers by gentle instead of jerking movement, and an octave action to use at pleasure the octave of the key struck.

491 is a seven-octave cottage pianoforte, with grand action and repeat, having a sounding-board and back on the principle of a violincello, &c., obtained by the application of an iron frame well secured between the sounding-board and the strings, which causes the sounding-board to tighten in a different manner from other pianofortes. The first *transposing* piano was invented by a German named Rolla. The keys in this instrument were *shifted*; the modern system is said to be very much superior. Of this 493A is an example. This is a pianoforte with transposing mechanism, metallic equilibrium string frame, adjusting tension rods, and improved sound-board, fitted in a newly-designed case with sliding front.

Pianofortes with metal frames are exhibited (496, 498). These are intended to carry the principal part of the weight or pull of the wires, independent of the wood frame, with a new screw apparatus for tuning attached to the same; particularly adapted to extreme climates.

499 is a semi-bichord grand pianoforte, upon the patent *overstruck* principle. In the ordinary pianoforte action the springs are struck from below; in this instrument the hammers strike down, hence the term overstruck.

The horizontal grand pianoforte (500) has a peculiar action, on an entirely new principle, giving increased power and certainty to the touch, and adding the tremolo, similar in effect to that produced by the voice.

550 is a model exhibiting the string-frame of an upright pianoforte, with lever tuning apparatus, the object being to sustain the pressure of the strings, and prevent the instrument getting out of tune. An upright piano, in which an apparatus is introduced to keep the instrument in a perfectly upright position; it is simple in action, and contains an apparatus whereby various degrees in quality of tone may be produced.

Harps and Stringed Instruments. (Exhibitors 496, 531, 533.)—Double-actioned harp (531), with additional notes. The double-actioned harp possesses greater powers of modulation than the single-action, and can also produce *enharmonic* passages; in which respect it is said to be a perfectly unique instrument, excepting those of the violin class. Every major and almost every minor key can be distinctly produced on it.

The triple-strung Welsh harp was an ingenious but laborious contrivance to enable the performer to take semitones, and to modulate into different keys. It is now superseded by the pedal harp, particularly that with the double action invented by Erard. The two outer rows of strings are diatonic and unisonic; the centre row comprises all those sounds necessary to complete the thirteen semitones belonging to each octave. This instrument is described by Mersennas in his 'Harmonie Universelle,' published in 1636. Of this kind is the grand triple-strung Welsh harp (533), worked in Welsh plane-wood.

Violins. (Exhibitors 509, 510, 519, 537, 541, 505.)—The following are the instruments of this class exhibited:—

A violin, viola, and violincello, made according to modern

improved gauges, after the models of the exhibitor's grandfather, popularly known as 'Old Forster.'

A violincello constructed upon principles said to produce increased vibration and superior quality and quantity of tone.

Violins, violincellos, and double bass, to exhibit oil varnish, said to be equal to that used on the Cremona instruments, the art of making which is supposed to have been lost.

Violin and violincello, and self-acting pegs for the tuning of violins, &c.

Violin and harp strings, said to possess all the qualities for which the Italian strings have been so justly celebrated.

There is one exhibitor (514) of an improved guitar. By means of two bars introduced within the instrument, and fixed in the blocks, greater strength is said to be secured.

Wind Instruments. (Exhibitors 504, 507, 512, 517, 520, 523, 535, 536, 538, 540, 546, 547.)—The first on this list exhibits a complete set of brass horns, with valves from soprano to contra bass, trombones with slides, clarionets, cornets-à-piston, and flutes on a new system.

Tromba cornuta, or drawing-room cornopean, long-valve trumpet, and double sax-horn, in A flat alto, and E flat tenor, are included in 507; the performer, while playing on the last-named instrument can, by using the extra valve with the left hand, without taking the instrument from his lips, glide from the alto to the tenor clef, and *vice versâ*, with facility.

Cambridge cavalry field-trumpet-bugle (512), is for executing trumpet and bugle field-calls, without having recourse to a second instrument. In the *bulb cornopean*, bulbs are substituted for angles, and curved passages are thus obtained for the wind, without enlarging the valves or increasing the friction, which is said to give improved quality of tone, and to facilitate the execution.

The modern brazen trumpet was invented at Nurem-

berg; but a similar instrument has been known from time immemorial.

The cornopeans, trumpets, and valve-horns exhibited (517), lay claim to an improvement which consists in the small diameter of the valves, the removal of angular turnings, and the quality of the metal employed.

Diatonic flutes, retaining the old system of fingering, while affording numerous additional fingerings, on a system said to be strictly based upon acoustic principles, may be seen (538). Their tone is said to be powerful and brilliant; they profess to be easier of execution, and therefore require less exertion to play than the ordinary flute. We have also—

(536.) Patent flutes, with new and old fingerings, possessing all the latest improvements arising from equidistant and equal-sized holes, and open keys; and an improved ordinary flute: its merits are said to consist in the novel proportions of its conical bore. Metal flutes have been sometimes recommended. Of these there are examples in 546, a silver flute, with rods, rings, and levers, equal to 12 keys, and a Stirling's British gold flute.

(547.) Newly-invented French horn, the novel feature being its portability, the loose crooks commonly used being dispensed with: to change the key, a continuous tube is graduated into 13 parts, each part being a semitone, at each of which an opening is made, into which is inserted a short tube, leading from the belt of the horn to the centre of the hoop, and then turning in any direction, which, receiving the wind as it passes through the horn, bears it away to the belt. A cornet-à-piston on the same principle.

Drums and Miscellaneous Inventions.—(Exhibitors 503, 504, 506, 508, 511, 516, 522, 527, 530, 531, 532, 548A.)

Amongst the drums will be seen a kettle-drum (527), which can be adjusted to any required note within the range of one octave, with rapidity and accuracy, and which also may be set to any note without sounding it: and a

bass-drum, both the heads of which can be tuned at once by one operation. Another, wherein the tension of the heads is quickly adjusted by means of iron rods, whereby permanent order is obtained; this drum contains cymbals, and both drum and cymbals can be used at pleasure, together or separately. Side, or signal-drum, with iron bracings, and two sets of snares, adjustable at once.

(503.) Æolian pitch-pipes — German silver, electro-plated, in sets; Æolian violin mute: the mute is a small instrument which is fixed on the strings of a violin, over the bridge, to soften and thin the tone. The uncertainty which at present exists with regard to the pitch is a source of great annoyance. The modern pitch varies from a half to a whole tone sharper than that used in the time of Handel.

The flœtina (508) is a newly-invented musical instrument, professedly adapted for concerts, and as an accompaniment to other instruments.

Centripetal regulating pegs and pins, which cannot draw back or give way, by which instruments can be tuned and regulated gradually in all their divisions in less than half the time formerly required, are exhibited (511). Also a spring "capo-tasto," for attaching to the handle of the guitar, changing at once the diapason of the strings, so as to play in all keys, without altering the printed notes, or the position of the hand and fingers.

Gioco di Eutérpe is a new musical game, intended to assist beginners in the knowledge of the relative value of musical characters, and to render them good timists. This will be found in 522.

(550.) A new and improved board for the violincello, and all other bowed instruments. The peculiarities consist of—1st. A groove running the whole length of the finger-board, which keeps the strings steady in one straight line, whenever a note is stopped on it: this is said to produce a good and clear tone, by rendering it more easy to stop each note firmly and well. Facility will be found

in changing the fingers from string to string in arpeggio passages, in stopping double notes, and in playing singing passages on one string only. The difficulty produced in all these cases by the strings slipping transversely under the pressure of the fingers, is well known to most players: the grooves are made with great care and accuracy as to size, shape, and position, under the string. 2ndly. In the adoption of a different form of cross section from that commonly used in finger-boards, giving it more arch; the degree of which, however, must bear a certain relation to the arch of the strings at the bridge: this alteration in form is said to produce a better tone on the first and fourth strings, and considerable facility in playing on the instrument in general. 3rdly. In the use of a long bracket, abutting against the lower end of the neck, and on the belly of the instrument, over the block, but no further, and extending under the whole of that part of the finger-board which lies over the belly of the instrument: the use of this bracket is to prevent the finger-board bending in playing passages which lie above the neck; it also prevents the neck from yielding under the tension of the strings.

Many ingenious inventions for assisting performers are exhibited, as—

(514.) Wrist-supporter, for securing a good position in playing the pianoforte: it is said to be of great utility to all young performers, the action of the machine not impeding in the least the movement of the fingers or the hands.

(541.) Self-acting pegs, whereby turning, instead of forcing, is sufficient to raise or lower the pitch of the strings; consequently that unpleasant revolving back of the peg is said to be completely removed: the construction is simple but effective.

And (532) the Norma Virium, or musical accentuator, is intended to supersede the metronome. It marks the first note in every bar, loud and distinct, in all measures

of time, and gives in weaker beats the sectional divisions.

Metronomes. (Exhibitors 148, 503, 532.)—These are pendulums for denoting time in music. 148 consists of a brass plummet attached to a tape 46 inches long, marked with metronomic distances from 360 to 55. By lengthening or shortening the tape, the vibrations are, of course, varied. Thus, by holding the tape with the finger and thumb at any number given upon it, allowing the plummet to swing, the vibrations will denote the time intended.

Surgical Instruments, &c.

In reviewing this portion of the Class, little more can be done than give a list of the articles exhibited.

The exhibitor of *artificial human eyes* (565), states they are made to fit in a few hours, without pain in the operation, in every case where the sight has been lost; the colour of the iris is well matched, and the resemblance to the natural eye good. The same exhibitor has artificial legs, much lighter, less expensive, and more durable than the common cork leg, enabling the wearer to walk, sit or ride with comfort; and we find similar claims for the artificial legs, crutches, hands, and various descriptions of surgical and anatomical instruments (676).

There is a considerable variety of supports in the form of (570A) corsets to be used in case of muscular weakness or slight distortion of the spine. Self-adjusting corporiform corsets, yielding with the body in its various positions, and resuming by itself its former shape and position, and contracting belts (570).

A new medical instrument is exhibited (649), for the purpose of rendering more efficient and certain the act of percussion in disease: by using the instrument with one hand, transmitted sounds can be employed in the diagnosis of diseases.

A clever universal drill, designed and made for the purpose of removing decay from teeth, to prepare them for

stopping, is exhibited (602): it can be used at all angles of the mouth without inconvenience.

Artificial teeth are exhibited by several: those at 720 are made of gutta percha, stated to be more durable than ivory, and from its softness far more comfortable; while 582 are artificial teeth, with gold masticators on suction principles; elastic gold lever, used for turning irregular teeth in the upper jaw; spiral spring, for correcting deformities in teeth.

Notice is called to the compound compensating swivel in No. 1 set of teeth, by which means the spiral spring is lengthened by yawning to accommodate that action; which is exerted when required by the operation of the muscles. By the ordinary swivel, no person can yawn without displacing both upper and under plates. Also, to the gold socket in No. 2, being a means of making the teeth wear three times the ordinary period of servitude.

The Mechanical Leech (646) is an ingenious instrument, said to be well qualified to supply the place of the ordinary leech, when the practitioner does not require to take a large quantity of blood, or where it is desired to draw blood from a difficult situation.

It is always available: the mode of using it is very simple; and any quantity of blood may be drawn in much less time than by the natural leech, with diminished risk of erysipelas. It is also important for use on ship-board, and in cases where the natural leech cannot be procured.

718 are a series of anatomical drawings. 591 is a spinal machine, with elastic spring crutches, for weakness of the spine. Extending knee instrument, for contracted knees. Elastic spiral silk stockings; ankle-socks and knee-caps, for relief and cure of varicose veins. Young ladies' boot, with steel plates, for supporting the arch of the foot. Moulded leather knee and hip splints, for confining the motion of the joints.

Mr. Simpson's large anatomical figures, in papier maché, showing the venous-nervous, muscular, and abdominal

systems of the human body, are highly instructive. These figures are extensively used to instruct the native surgeons in India in anatomy, many reasons preventing the study from the dead body in that country.

There is also a series (625) of anatomical models, showing several parts of the human body dissected—skulls, and eggs in various stages of incubation.

631A is a complete cabinet of surgical instruments, containing those necessary for every operation in surgery; so is also 631—including Dr. Wagstaff's tongue-depressor, and probangs for the application of *lotio argenti nitratis* to the air-passages, and apparatus used in orthopedic surgery, showing the latest improvements for the treatment of contraction of the neck, hip, knee, foot, arm, and hand, including apparatus for lateral and posterior spinal curvatures.

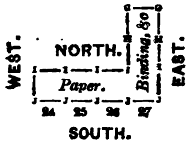
The stethometer (682), an instrument for assisting in the diagnosis of diseases of the lungs, by measuring the comparative mobility of opposite sides of the chest; and cautious surgery has provided (628) railway tourniquets, for the application of pressure in cases of accidents. Here is, also, the aneurismal compressor, for the cure of aneurism by compression. The ease with which the instrument can be used, and the pressure regulated at pleasure, is its chief recommendation. Dilators for stricture, oyster-opener, &c.

Beyond these we have the bedstead, which, by the hand of a watch, is adjusted to turn a person out of bed at any hour, and can be applied to a common bedstead at a moderate cost; and, in 614, the Devonia bedstead, for invalids. It lifts the body, so that the bed may be made up under the patient, and it rises at the head and back, so that the patient can recline in any position most easy to himself. These changes can be effected by the assistance of one person.

The patent fulcrum-chair, to render less painful, and facilitate the extraction of teeth, is cleverly devised, and

(619) is an apparatus for regulating the temperature of morbid parts, and causing equal pressure: this instrument is used in the application of a benumbing temperature, in the treatment of cancer, &c., it being found that the regulated application of a temperature below zero, of Fahrenheit's thermometer, is a certain, safe, and prompt remedy for inflammation and pain, and it has been employed in many cases most satisfactorily, and is stated to be a substitute for chloroform in surgical operations.

Class XVII.—Paper, Printing, Bookbinding, &c.—*With portions of Class XXX.*



Situation of Class.—*On the Northern Side of the Main Avenue, between Pillars* I, *and* J., 24 *and* 28, *running back between* 27 *and* 28 *to* G.

Passing the envelope-folding machine, which is to be seen at work in the Nave (to which we shall refer presently), we will invite the visiter to enter with us while we point out the different objects in as near as we can the order in which the said materials of paper, type, and ink are used, in the production of the printed books which disseminate information and amusement among millions.

Begin we then with *Paper.* (Exhibitors 27, 29, 36, 42, 42a, 76, 84, 96, 101, 102, 143, 147, 149, &c.)

On entering the space allotted to Class XVII., the visiter cannot fail to observe the immense roll of paper suspended from the Galleries, made in a continuous sheet of 2,500 yards long, and 46 inches wide, which is to be seen at the opposite corner to the envelope folding-machine. This forms a good preparation for the contemplation of the manufacture of this important article, which we are now about to notice, as showing the perfection of the machinery in thus producing from the liquid pulp an unbroken sheet of any length required. There are other long lengths of paper of various kinds "in the web," or continuous sheets, which are also well worth inspection; but we will proceed upon the plan proposed, and commence our survey with the first stages of this important manufacture.

A very interesting collection (149) meets the visiter

on first entering the compartment. It consists of specimens of the present state of the paper manufacture in Great Britain, as well as of the materials employed in it, in various stages of preparation. Foul rags and other matters are here shown in strange contrast to the pure white of the manufactured paper. Here too, amongst other "paper materials," is shown a piece of the cable of the "Royal George," and coarse paper made from it—objects worth the notice of those who value relics.

The introduction of paper-making machines, as the word is now understood, is of recent date; a model exhibited in Class VI., which is on the principle by which almost all paper is now made, was patented in 1806. Till within a very few years before this, paper was made almost entirely by hand. And though many improvements had been made in the art since its first discovery by the Chinese (who are supposed to have been the inventors of paper), A.D. 95, it is not in our province now to detail these; but to notice the process through which paper, as now manufactured, has to pass. The first operation is to cut the rags or other materials into small pieces. Then, after having been thoroughly washed, they are conveyed to a cylinder furnished with sharp teeth or cutters, which revolving against other teeth, the rags are reduced to a thin pulp. The pulp, or "stuff," as it is technically called, is then moulded into the form required for the future sheet of paper, upon a frame and rollers covered with wire-cloth, the patterns on which form what is called the "watermark" in paper. The superfluous water draining through the wire-gauze leaves the pulp of a proper consistency for the subsequent operations of pressing, &c. Many specimens of these "dandy-rollers," as they are termed, of pulp-strainers and pulp-meters, and of other portions of paper-making machinery, are to be seen amongst the articles shown in Class VI.

The specimens of paper exhibited include printing-papers, writing-papers, and others (showing contrivances for autograph water-marks and other novelties). Another

branch of the paper manufacture represented is the tissue upon which the designs for pottery and earthenware are first printed, thence to be transferred to the unglazed ware (147, and Class VI., 100). Specimens are also shown of the coarse papers made from old ropes and such-like fabrics, and used for packing; of glazed-boards, employed in pressing cloth; of gun-wadding; of the blue paper used by starch-makers, which has to undergo the process of baking in contact with the moist starch without losing its colour; and of other coarse descriptions of paper. 29 is an exhibition of paper rendered water-proof by the employment of a newly-invented size.

The importance of the paper manufacture of Great Britain may be estimated by the following facts. About 130,000,000 pounds weight are annually made in this country, the value of which is estimated at upwards of 3,000,000*l.* sterling. About nine-tenths of this quantity are used in home consumption; the exports not exceeding 300,000*l.* Paper made in the United Kingdom yields an annual return to the revenue of 870,000*l.* Of cards, drawing-boards, envelopes, and ornamented papers, we shall have to speak when on the subject of fancy stationery.

Let us now proceed with the next of the great requisites in the production of printed books.

Type. (Exhibitors 22, 78, 90, 92, 94, 124, 150, 181, 182, 184, 195, &c.)—Some of these show the type itself, but the greater number of our founders have contented themselves with sending (more comprehensible to the majority of visiters) samples of the work printed therefrom.

Type, as many of our readers doubtless know, is cast in mixed metal composed of lead, tin, and antimony. The character to be cast is first engraved on a hard steel punch, which, struck upon a piece of copper, forms a matrix or reverse for the future type. This matrix is then placed in a mould of the size required for the letter to be cast, into which the type-founder pours the melted metal. 124A and 195 exhibit the matrices and moulds thus em-

ployed; and 78 shows the mould used in 1720, contrasted with that of the present day.

In Class VI. may be seen a machine for making type from copper, zinc, or other metal in a cold state, the matrix being used as a die, and the type struck something after the manner employed in coining.

124 illustrates the exactness with which type can be cast, in a super-royal "form" of the very small type called "pearl." This "form," which weighs 140 lbs., and consists of above 220,000 separate pieces of metal, is supported only by the lateral pressure of "locking-up" (screwing into an iron frame or "chase"); a process that obviously could not be accomplished were not every type perfectly square. Of extremely small (we may say microscopic) type-founding there are two specimens, 92 and 150, each of which is declared to be the smallest ever cast in this country. They are respectively called "Gem," and "Brilliant," and an idea of their size may be formed from the fact, that in one of them (cast by the new type-casting machine, patented by Mr. Richards), Gray's "Elegy," consisting of 32 verses, is contained in two columns 3¾ inches deep. Every letter a separate casting, and the whole perfectly legible! 22 is an original design of a series of letters called "Arabesques;" and amongst the collection are to be found a set of Elizabethan or Church text, with initial letters of the Tudor period; ornaments from the remains of Nineveh and Etruria, and other specimens of fancy typography. 78 contains some specimens of borders printed in three or four colours. 94 shows a plan for printing from type in two colours, by making the letters of different heights, so that the inking roller in passing over the form, shall only touch those types which are to be printed in the one colour. 181 has a variety of fancy borders, and specimens of plain and ornamental typography are shown by 113, 136, 140, 180, 187, and others. 140 gives us King Edward VI.'s Book of Common Prayer; coloured diagrams of the first six books of

"Euclid;" with specimens of the missal ornaments, dresses, and decorations of the middle ages. 180 is the speech lately delivered by H.R.H. Prince ALBERT, at the Mansion House, in English, French, German, Turkish, Arabic, and several other languages, exhibited as a specimen of the application of typography to various characters.

Brass rules (used for printing the straight lines in tabular work, or the divisions of columns in newspaper and book-work) are shown (187), arranged in company with pieces of those segmentary ornaments called "combination borders," forming a representation of the front of the Free Church College, Edinburgh. The outlines, shades, and other effects, are all produced by these means, upwards of 12,500 pieces of metal type, and 80 feet of brass rule, being employed. 78 has a machine for cutting brass rules to the proper length, and for "mitering" or forming the angle at the end to make two rules join closely when arranged in the form of a border.

Several purposes, for which it has been found extremely difficult to employ moveable types, remain to be noticed. These difficulties have principally arisen where it has been required to imitate by typography the works of the pen. Calligraphic, or "script" type, is one of these. The difficulty of making moveable types, which when set up should give to the letters the continuous appearance of written words, each letter joined to the next, has often called forth the ingenuity of the type-founders. 78 shows type of this description, in which the difficulties are apparently very well disposed of. Music, too, requiring as it does, whatever notes be printed, a continuous stave running the whole length of the line, requiring also in many instances the most unexpected forms and combinations to express the different musical phrases, has long been another stumbling-block. Of this description of type, however, there are several good specimens exhibited (22, 77, 92, 127, and others). Some notion may be formed of the difficulties attending the printing of music by moveable types, when

we mention that, in one of the cases above alluded to, 253 different types are employed, consisting of dots, strokes, curves, &c.; while in another the number of different types is 315. Between these types there is frequently so little perceptible distinction, and yet this difference is so important to the appearance of the work, that no ordinary care is required on the part of the compositor in setting it up. A specimen is also shown of printing inscriptions (copied from some in the British Museum), in the cuneiform character, by means of moveable types, which is very satisfactory. Typography, applied to the printing of Persian, Syriac, Arabic, and other characters, is also exhibited; and the Chinese language, with its alphabet of some 80,000 signs, is represented also by the use of moveable types. Two attempts are to be seen (60 and 197) to reform the spelling of our own language, and to introduce more or less a new alphabet. These are the phonological and the phonotypic systems of printing. Of their respective merits it is not for us to speak; our subject at present is typographical, not philological. We mention them among the other varieties of type exhibited. One or two specimens of wooden type are also shown. And the "Hymn of all Nations" is exhibited as a specimen of typography in fifty different languages.

Some improvements in the apparatus for setting up the types are shown—11 is a portable frame for holding the cases; and in Class VI. is a proposal for introducing the principle of a division of labour into the compositors' duties, by leaving the type when set up to be "justified" (the process of increasing or diminishing the space between each word, in order to bring the last word exactly to the end of the line), by boys' or other inexpensive labour.

Stereotyping, &c. (Exhibitors 107, 124A, 128, 174, 195, &c.) —Closely allied to type-founding are the arts of stereotyping, polytyping, electrotyping, and similar contrivances for getting solid casts from the surface of the moveable types. In the first of these branches there are some very

good specimens (107), which show the sharpness with which the face of the type, wood-cut, or other raised surface can be reproduced from the plaster mould. Under the same number we find a stereotype plate for printing in two colours at one impression, for show-cards and similar work. Portions of the plate are contrived so that they may be readily lifted off and inked separately, and as readily fixed on again to pass through the press. One novelty in connection with this is, that the letters (which are white) are not engraved, but are produced by a process which the inventor keeps secret. 128 is a new process of bituminous polytyping, in which the printing surface itself is a bituminous compound: 189 are very delicate casts in a fusible metal from lime-wood matrices; 174 is an electro-stereotype plate of a page of "diamond" type (the smallest used) from a gutta-percha matrix, which was taken from the type in a screw-press. A still more extensive application of gutta-percha for this description of process, though exhibited (in conjunction with a printing machine) in Class VI., is to be noticed with the class we are now considering. Here the printing surface itself is made of this material. A gutta-percha matrix is first taken from the surface of the type, wood-cut, or whatever is to be printed. This matrix is then put into a "patent cylinder press," with a cylinder of gutta-percha in contact with it. By this means the cylinder is moulded by the pressure into the form of the matrix, and becomes in fact a cylindrical stereotype of gutta-percha. From this cylinder the work is printed on paper "in the web" in a patent press (also exhibited), which cuts the paper when printed into sheets, and finally folds it into the required form. 40 is a print from a stereotype plate, taken from medallion or machine engraving.

Printing-ink (Exhibitors 31, 65, 78, &c.) is exhibited in black and colours, but, like the type, its excellence is much better shown in the printed work.

Writing and other Inks. (Exhibitors 7, 80, 110, 119, 155,

176, 179, &c.)—60 is a chemical ink for writing on paper or parchment besmeared with grease, adapted for butchers, oilmen, &c. 176 shows specimens of writing-ink which have been tested by various acids, without being in any way affected by them: exhibited as a security against fraud. 155, specimens of marking-ink.

Printing presses and machines are shown in Class VI., to which we would now refer the visiter for the next process in book-making.

The specimens shown of lithographic printing, of chromo-lithography, of printing in colours from wood blocks, and other descriptions of ornamental and artistic printing, are very beautiful and extremely interesting. The perfection to which these arts have now been brought, the niceties of shade in the various tints produced by printing one over the other, and the general excellence of the products, are something wonderful. These specimens have been most appropriately placed in the Fine Arts' Court. (Class XXX.)

Bookbinding. (Exhibitors 5, 8, 24, 26, 35, 43, 48, 59, 62, 67, 68, 89, 91, 97, 103, 106, 109, 111, 117, 118, 134, 135, 139, 158, 196, &c.)—The collections are numerous and good. Some of the bindings being particularly beautiful. Inlaid leather, and leather stained in imitation of wood, are shown as the covers of books. A clock-case, too, in leather, ornamented with bookbinders' tools, is shown in this department. 24 exhibits the different stages through which a book passes in the process of binding—the sheets folded, sewed, put into boards, cut, head-banded, pasted down, and finished. Designs painted on the fore-edges of books are also shown, and many varieties of ornamental bindings. 194 is a large portfolio fixed on a bracket, and opening from the wall. A Bible, bound for William IV., with a representation of the "Sailor King" on the cover, is handsome. In 67, we have an attempt at making the outside of a book give an illustration of its contents, by using ornaments in accordance with the era or the subjects of which it treats; and, in 158, we have

gutta-percha bindings in imitation of carved ebony, and samples of the method of ornamenting the covers of books by machinery, the design being engraved on a dye, the impression from which is produced at a single blow. The application of electrotyping to the ornamenting of book covers is shown, as are also covers of solid metal. Two books bound together back to back in a curious manner, called the "Siamese" binding, and ecclesiastical books bound in carved wood and polished oak, are also exhibited. Cloth for bookbinders' use (56 and 69), patent head-bands made by machinery (61), millboards, &c. (42), and other materials, are also to be seen in this department. A Bible, with a cover most beautifully carved in box-wood, is placed among the Fine Arts, as are also some good specimens of decorative binding.

Account Books. (Exhibitors 34, 44, 46, 53, 86, 101, 159, &c.)—We have specimens of commercial books of all kinds and of all sizes, from the "monster ledger" to the smallest pocket-book. Different processes are shown under various patents for contrivances to prevent the leaves from breaking away from the binding, and to insure the books opening perfectly flat—a point of great importance in account-books, wherein it is requisite to write in the inner columns. 32 and 38 display metallic pocket and memorandum books.

Fancy Stationery. (Exhibitors 1, 17, 18, 27, 33, 41, 49, 76, 79, 101, 102, 137, 142, 160, 177, 190, &c.)—Let us now take a glance at the departments of cards, envelopes, embossed paper, and fancy stationery in general. We will begin with the machine for folding envelopes, exhibited in the Nave, to which we have before alluded. On first seeing this machine folding the flat pieces of paper into envelopes, at the rate of from forty to sixty in a minute, the spectator feels almost inclined to doubt the policy of constructing so powerful a machine for so simple a purpose as the folding of an envelope; and to wonder how the consumption of so trifling an article (universal as

is its use) can possibly be sufficient to employ such engines in their manufacture. This wonder will probably be considerably diminished when he learns that about *three hundred millions* of letters enclosed in envelopes pass through the Post-office in the course of the year! Add to this the numbers conveyed by hand for notes, circulars, &c., which are estimated as being about equal to the number sent by post, and we have the extraordinary amount of *six hundred millions* of envelopes as the annual consumption of this country!

The machine before us folds upon an average 25,000 envelopes in a day (of ten hours), and so true and exact is its mechanism, that of this quantity the average number of envelopes spoiled is only 12.

Let us see the working of it. The paper is first cut into the form required for the envelope. This is not done at the machine, but by means of a steel punch or form of the required shape, which is pressed forcibly down upon the heap of paper by a powerful hand-press. The initial letter, or other device impressed upon the envelope, is also stamped prior to its being taken to the machine. This done, a heap of these papers, or "blanks" as they are called, is laid upon the table of the machine. The boy who feeds it then takes one from this heap and lays it upon the small iron platform, which rises and sinks in a rectangular cell in the centre of the machine, having guides to convey the envelope to its proper place. The platform sinks, and at the same moment a plunger fitted into the hollow caused by its descent (and balanced by counterpoise weights) falls down, and forces the paper into the hollow, thus doubling up the four flaps of the future envelope, and making a rectangular crease which marks its form and size. But this is not enough. The flaps are now in a vertical position. They have yet to be gummed and folded down upon each other. To admit of this the plunger now separates into two portions, the ends rising to allow of the two end "folders" (which are shaped like the flaps

of the envelope) to turn down the two end flaps, the sides of the plunger meanwhile holding the envelope down. The two folders perform their office simultaneously to all appearance, but not so in reality. The one to the right of the boy feeding goes first; by this means the flaps must of necessity fold properly over each other, otherwise by meeting half way they might be creased back and destroyed. The "gumming" is the next process. The "gummer" is a piece of metal cut in the form required to be taken by the gum to cause the proper portions of the envelope to adhere. It is supplied by an endless strip of cloth or felt revolving in a small trough containing the gum. It now descends upon the two end flaps, applying the gum to them. The portion of the plunger which had been left behind and the "gummer" then retire together to make way for the operation of the two side-folders. These descend upon the envelope (the one nearest the boy taking a slight precedence), and the folding is completed. The end folders have till now remained upon the envelope. The four folders open together, and the taking-off apparatus at the same instant moves forward. This consists of an iron rod, with a transverse one fixed to its end. Two "fingers" (small pieces of iron tipped with vulcanised Indian rubber) descend from the transverse rod, and being lightly pressed upon the envelope, the slightly adhesive nature of the caoutchouc enables them to lift it off the platform, and, again receding, to convey it to the heap of folded envelopes, placing it underneath the last formed. The edge of each envelope as it is taken to the pile is by this delicate apparatus allowed to project somewhat so as the readier to admit of the next folded one being placed under it. The envelopes when folded are conveyed by an endless blanket working across the machine to a pair of rollers between which they are pressed. They then form themselves by the unaided action of the machine into a regular pile in a trough, whence they are taken out in a finished state.

Another of a somewhat similar description is exhibited in Class VI. It differs from the one we have described in several particulars. In the first place it has a self-feeding apparatus, which is very curious. The heap of "blanks" is placed upon a small platform, which rises at each operation of the machine, and brings the uppermost sheet in contact with a hollow arm. This arm is connected with a small apparatus resembling an air-pump, which, creating a partial vacuum, causes the paper to adhere to the arm by the pressure of the atmosphere. The arm advances, and conveys the paper over the cell where it is to have its form given to it, when the action of the vacuum apparatus is reversed, and the paper thereby deposited in its place. The flaps are not in this machine turned down by the folders as in the other, but by a second descent of the plunger upon them—an action which hardly seems so certain—certainly not so rapid as that of the folders. The gumming apparatus, too, is slightly different from that we have described. And the finished envelopes are not pressed and piled into a heap, but drop into a box, and have to be gathered, and afterwards pressed by hand. In this machine a die descends, by the same motion with the plunger, and stamps the envelope with the device required.

But we will resume our notice of fancy stationery at the spot whence we strayed to mention the companion machine to that which forms so prominent an object in the collection we were examining (76). Here we find note-paper embellished with very elegant and artistic designs in the water-mark—an art of modern invention—and most beautiful designs in playing-cards (by Owen Jones). Some playing-cards are exhibited on the novel principle of printing every suit in a different colour. Embossed paper, and cards, envelopes, &c., are shown, and some fine enamel coloured papers, very artistically arranged. But by far the most interesting contribution from this exhibitor is the new process shown of the production upon paper of prismatic and chameleon-like colours, changing

with every variation of position (177). The principle upon which this process depends is that which was explained by Sir Isaac Newton in accounting for the beautiful prismatic colours exhibited by a soap-bubble—the extreme thinness of the film. In the paper now under our notice, the colouring matter (if, without making a "bull," we may use the term) is a colourless varnish, which is spread first upon water. The paper, or other matter to be embellished (for the exhibitor shows the application of it to metals as well as to paper), is drawn through this, and the film of varnish adhering to it causes it to exhibit the most beautiful iridescent colours. The paper exhibited is of different tints: some of it is white; and a shell made in this has a most perfect resemblance to nature. 42 has a large collection of envelopes, note-paper, and other fancy articles. 102 shows some writing-papers ornamented with wreaths of flowers in the water-mark; and artistic water-marks are also shown in a transparent screen (160). 49 displays a frame filled with playing-cards in gold and colours. Valentines are exhibited in considerable variety, and the embellishment of some of them is very elaborate, consisting of perforating embossing, stamping in imitation of lace, crochet-work, &c. Illuminated note-paper (33), and note and letter paper (101), ornamented with views in oil-colours, are to be noticed. 79 contains specimens of embossing (plain and coloured), exhibiting, amongst other subjects, one of Raphael's cartoons. Lace-bordered cards and paper are also to be seen here.

A machine for forming the dome-shaped lamp shades from flat paper discs, some imitations of different fancy woods printed in colours from wooden blocks, and some very perfect imitations (in printing) of lace, muslin, &c., are shown in Class VI., as is also a patent folding machine. We glance at these as being connected with the Class we are now noticing, although not included in it.

137 shows three different kinds of self-sealing envelopes having moist cement contained in a tinfoil capsule. 142

is the "registered polychrest envelope," comprising in one piece of paper both note and envelope.

12 is a postage-stamp machine contrived as an expedient for saving time. It is so arranged, that on dropping in a penny, the machine most honestly and conscientiously delivers one stamp. 47 shows a manifold writer, with specimens of the copies taken by it. And 121 is a portable letter-case containing paper by which a copy of a letter written in ink can be taken by the mere pressure of the hand. 51 are perforated plates for marking linen; and in 156 we find a new description of manifold writer made on the principle of the pentagraph, by which several copies may be written with pens at one operation on separate sheets of paper. 41 and 64 exhibit tracing cloth. 1 has a very handsome and very large colour-box, and other requisites for artists, a scrap-book, &c. 45 has different kinds of drawing-boards; 63, an artist's multum-in-parvo, containing a seat and other conveniences, with the various materials required for sketching. Scrap-books are shown (88, 108). Specimens of engraving and illustrating music (123 and 183). An almanac printed upon vellum in gold (186). And newly-invented ink-bottles (165). Sealing-wax is shown by 21, 73, 93.

Several other articles are exhibited in this class which though not exactly shown as specimens of paper or of printing, still are either connected with them or produced from them. Amongst these the visiter will observe several inventions for enabling blind people to read, write, calculate, write music, &c. (20, 47). Dr. Foulis's tangible ink which produces raised characters upon the paper for the use of the blind, is to be found among these (170), as well as various alphabets, system of musical notation, &c. (171, 198). School outlines too, for teaching drawing (185), which are stamped in the paper, are shown in this Class; so are copy-books with printed headings (83), and several specimens of penmanship (178, 199), and some copies of engravings excellently executed with a common pen, by a

late pupil of the Glasgow Deaf and Dumb Institution (200).

23 contains some examples of 'a very curious process of splitting the thinnest paper evenly, without damage to either side of the sheet.

36 exhibits safety paper for banking purposes, and some extra strong paper used by Government for foreign despatches, a sheet of which weighing only 1¼ oz. is said to have supported, without tearing, a weight of 5 cwt. 24 lb. suspended from it.

10 is a very extraordinary process:—A bank note is exhibited, printed apparently in two colours, a neutral tint for the back ground and black for the letters; and yet these two are produced at one printing, from one plate, at one press, and with one inking. It is recommended as being so much cheaper than a plate worked off at two different printings, while the peculiar nature of the ink (which is a water-colour) is such as to render it a good preventive of forgery, as it immediately detects any attempt to tamper with the writing by means of acids, or otherwise. Specimens are shown of the effects of different tests upon the colour.

201 is an interesting collection of 183 books in different languages, consisting of the 175 versions of the Holy Scriptures, either in whole or in part, which the British and Foreign Bible Society has been instrumental in publishing; and eight specimens of English Bibles, showing the improvements of printing, &c., from the year 1816 to 1851. Near to this collection is that of the Religious Tract Society (154), consisting of religious books in the principal languages and dialects of the world. The polyglot Bibles too (87), printed in separate volumes, and corresponding page for page with each other, form an interesting collection.

Several machines exhibited in Class VI. for cutting cards for printing and other purposes, for cutting, printing, packing, numbering, and dating railway tickets, &c., may be

noticed in connection with the branch of manufacture we are considering. Copying presses also in considerable numbers; cutting machines, for paper or millboard, for bookbinders and other purposes, for cutting paper in the continuous sheet for ruling.

Maps in large numbers are hung in all directions about the walls of the space allotted to Class XVII., principally contributed by 4, 66, 74, 175, 191, 192, 193; and amongst the collection of printing, &c. (136), is a relic or autograph that would be highly esteemed by collectors of those matters. We allude to Mr. Paxton's first sketch of his design for the Crystal Palace, roughly drawn in pen and ink upon a piece of blotting-paper, from which we are told the drawings and elevations were copied to be sent to the Royal Commissioners.

Maps in the Exhibition.

The position of these Maps will be stated at the head of each description.

Exhibitors.—England, Class I., 159; Class VIII., 129; Class X., 160; Class XVII., 4, 37, 66, 74, 109, 191, 192, 193; Class XXX., 232, 263, 335.

France, 804, 1072, 1238, 1635, 1653.

Austria, 363, 364, 365, 368A, 372.

Belgium, 437.

United States, 143, 215, 310, 360, 477, 505.

Zollverein, Class I., 158, 290, 303, 432; Class III., 184; Class VI., 6.

Switzerland, 42.

The importance of this Section of the Exhibition, although not amongst its more striking attractions, is so exceedingly great, that the following description of these very valuable works, which has been drawn up with much care, is introduced in this place, under the impression that it will serve immediately to direct attention to things which might otherwise pass unnoticed, and be a record of a collection which it is not probable can ever again be brought together.

ENGLAND.—The Government map of England and Wales (at the end of the West Gallery), is engraved on copper on the natural scale of $\frac{1}{63360}$, or 1 inch to a mile; the hills are represented by vertical "hacheurs," and the altitudes of the principal points given.

The map of Lancashire is on the scale of 6 inches to a mile. This shows all the civil divisions of the county, with every field, and almost every tree in the county. The altitudes are represented by *contours*, which are lines of levels traced round the hills, and into all the sinuosities of the ground: they are taken at different altitudes, at 25, 50, or 100 feet above the mean level of the sea, and it will be seen by the models made from the data furnished by the contours, that they accurately represent the configuration of the ground, and the relative altitudes of different points on it.

The map of Liverpool is on the scale of 5 feet to a mile; every house, outhouse, garden, &c., is given with the minutest detail, and the levels are engraved along all the streets.

The whole of Ireland has been engraved on the scale of 6 inches to a mile, and most of the principal towns have been drawn on the scale of 5 feet to a mile. The plan of Dublin is on this scale, and is very highly finished. The survey of Ireland is the most perfect survey of a kingdom that was ever made. All the civil divisions of the country are shown on it, and their acreage given; and as the boundaries of private estates are generally the same as those of the townlands, the Government may be said to have furnished a special map of every estate in the kingdom; and such is the confidence placed in it by the public, that transfers of property are made without incurring the expenses of special surveys for the purpose. Numerous altitudes are given on the plans, so that lines of railroads, canals, or drainages, can be laid off with perfect certainty, whilst as a basis for the valuation and registry of property, and for social improvements of many kinds, they are unrivalled.

The electrotype plates and the impressions from them,

show the perfection attained in this art, and the ready means it affords for multiplying copies of plates.

The Admiralty exhibits a series of the printed charts, from the Hydrographical Surveys, of almost every part of the globe. They demonstrate the scientific attainments of our naval officers, and the enormous amount of labour which has been expended in perfecting our charts; that of the Atlantic, showing the lines along which the variation of the compass is equal, and the difference in the amount of the variation in different places, is no less interesting than valuable.

The Geological Map of part of England and Wales, exhibited in Class I, is the Government Survey, and is executed in a very superior manner.

The Geological Survey of the United Kingdom is now in progress, under the direction of Sir Henry De la Beche, with whom the work originated. Electrotype copies of the Ordnance Maps being obtained, the geological boundaries are laid down with great accuracy, and engraved upon them, together with the mineral lodes, the outcrop of the coal, faults, and much other valuable information. These maps, therefore, represent most faithfully the geological and mineralogical condition of the country over which the survey has been extended, and they are, to the practical miner and to the agriculturist, of the utmost value.

The map of England and Wales, scale half an inch to a mile (74), is a good general map of the kingdom. The schoolroom maps, by the same exhibitor, are very clear and distinct.

The schoolroom maps (4) of the Royal Naval School are also very good, clear maps for the object, which is to embrace physical, political, and industrial information.

Mr. Wyld exhibits a well-executed map of England, and another of the world, with a popular atlas, got up in an inexpensive manner. His coloured railway map of Great Britain is very good, but the map of the Pyrenees does not appear natural.

Adshead's illustrated map of Manchester, scale 1 inch to

66 feet (328), is a useful map for local purposes, but is roughly drawn.

The map of London (335) is a clear map for general purposes; and the map of London (192), with tables of distances, is also a useful map for reference; while the map of London and Westminster (191), compiled from old maps and records, representing the city as it was in the reign of Elizabeth, is very interesting, and well engraved.

The map of Ipswich (1), by Cowell, is printed from a plate produced by the anastatic process from the original pen-and-ink drawing, and is a good example of this method of reproducing fac-similes.

The isometrical projection of the world (66), by Candy, is very ingenious, but distorts the plans.

M'Dermot's survey of the estate of R. J. Wason, Esq., at Corwar (188), is a good example of an estate map.

FRANCE.—The government map of France is on the scale of $\frac{1}{80000}$th, or $\frac{4}{5}$ths of an inch to a mile. It is engraved on copper, and the hills are represented with vertical "hacheurs," as in the English maps: they contain great detail, and are beautifully executed.

The index is on the scale of $\frac{1}{1600000}$th, or about $\frac{1}{12}$th of an inch to a mile; the principal triangulation and the bases measured at Dunkirk, Melun, Brest, Marseilles, Bayonne, and Perpignan, are shown upon it.

The hydrographical charts are beautifully executed; those of the coasts of France are bound in folio volumes, and are known as 'Le Pilote.' The charts of the Gulf of Spezzia, and of the Shetland Islands exhibited (126), are good examples of the French style in which the charts are executed.

The Government has also had special maps made of different parts of the country on larger scales; that of St. Cloud is on the scale of 12·68 inches to a mile; the Department de la Seine is on double the scale of the general map, or 1·6 inches to a mile. To illustrate the descriptions of battles, that of Craones is on the scale of 1·6 inches also;

that of Montmirail on rather more than 3 inches to a mile. The plans of the towns of Moulins, Rennes, Vesoul, and Orleans, are on the scale of $\frac{1}{20000}$th, or 3·2 inches to a mile.

894 is a beautiful lithographed map of Lyons, on the scale of $\frac{1}{10000}$th, or 6·3 inches to a mile.

(544.)—Six sheets of the geological map of France, by Dufrénoy and Elie de Beaumont. These are coloured by lithographic printing. The geological map of the department of the Bas-Rhein, on the scale of the general map, is coloured in the same manner. These are from the "National Printing Office, Paris."

The lithographed map of Algiers and its environs, compiled from the surveys and reconnaissances of the officers of the Etât-Major, is well executed, and is the best published map of that country.

39. Bauerkeller exhibits 14 coloured maps in relief of different parts of the world. They are neat and prettily executed, but cannot aim at much accuracy.

AUSTRIA. (363.)—*Maps of Lombardy and Venice.*—The Government maps are engraved on the scale of $\frac{1}{86400}$, or not quite 3-4ths of an inch to a mile. The hills are represented by vertical "hacheurs," darker from the light: these plans contain great detail, and are very clear good maps, but no altitudes are given.

The latitudes and longitudes on the borders are given to one minute.

The lithographed plan of *Vienna* and its environs, on the scale of about 4 inches to a mile (the scale is not stated), is printed in colours, distinguishing the class of the houses, as brick, stone, or wood; and also the soils and localities producing the different crops, as wine, wheat, beans, &c.

Bohemia.—There are no impressions of the Government Survey of Bohemia, but the engraved copper sheets containing the city of Prague, and the electrotype matrix plate from it, is exhibited as an example of the mode in which plates can be multiplied.

The scale is not stated, but it appears to be about 3-4ths

of an inch to a foot. The hills are represented by vertical "hacheurs," and the whole very well engraved.

(370.) *Statistical Maps*—of Austria, by J. Bermann, of Vienna.

The population is divided into classes, as aristocracy, beaurocracy, clergy, merchants, teachers, agriculturists, &c.; the maps distinguish by colours the relative density of the population, and of each particular class in each district, and separate indexes give the number of each particular class, in each part of the empire.

Map of Austria—distinguishing the provinces in which the five different languages are spoken, viz.:—German, Italian, Hungarian, Sclavonic, and Wallachian.

(365.)—Large map for teaching, printed in colours, from wood blocks: the writing is done by common types set in the blocks; they are thus able to use the same blocks for maps in different languages—Rafflesberger.

These are clear good maps for teaching.

ITALY.—Lithographed special map of the centre of Italy, on a scale of $\frac{1}{86400}$, or 3-4ths of an inch to a mile, constructed from the trigonometrical survey at the Imp. Roy. Mil. Geo. Inst., Vienna.

Map of Europe.—Lithographed and printed in colours, by J. Scheda.

(364.)—*Map of Italy*, by Corri, C. of the Imp. Roy. Mil. Geo. Inst. A good clear map, scale $\frac{1}{864000}$th, or 3-40th of an inch to a mile.

(372.)—Coloured lithographed maps of *Carniola*, by Müller, of Vienna; the hills are represented by stippling in brown, the rivers blue, and the roads red—they are well executed, and apparently accurate maps.

The *Geological Map* of part of Styria, lithographed, and printed in colours, shows how well adapted this process is to the purpose.

(363.) *Plan of Paris.*—A beautiful lithographed map of Paris, scale $\frac{1}{192400}$, or 1-3rd of an inch to a mile; apparently copied from the general map of France.

(437.) Belgium.—The Government map of Belgium is engraved on copper, on the scale of $\frac{1}{80000}$th, or 4-5ths of an inch to a mile.

A diagram of the triangulation is published with the sheets, showing its connection with that of France towards Dunkirk and Longwy.

The hills are represented by "hacheurs," as on the English maps, but there are no altitudes on the plans.

The latitude and longitude is engraved on the margins, and meridians and parallels are drawn across the sheets.

The name of the principal town in each sheet is written at the head of the sheet: this assists the memory much better than a number only.

Antwerp, plan of, on a scale of $\frac{1}{2500}$, or 25·3 inches to a mile. This is a clear good plan, but there are no altitudes on it. The divisions between the houses are shown, and the public buildings are engraved darker than the others.

Prussia.—Sheet of the Government map, on the scale of $\frac{1}{25000}$th, or 2½ inches to a mile. The hills are represented as on the English maps, but no altitudes are given; the outline is remarkably clear and well executed, but the hills are not so.

We understand, however, that the Prussian government contemplate a geological survey on the strictly accurate plan pursued in this country.

The lithographed sheet of the survey, containing the city of Dresden, on the scale of $\frac{1}{50000}$, is well executed.

Jöttnig and Kraatz.

An atlas of maps of parts of Germany, by S. Schropp and Co., Berlin.

Geological maps neatly coloured, but the geology is evidently nothing more than a mere sketch.

Saxony (184).—The government survey is engraved on the scale of $\frac{1}{57600}$ or 1·1 inch to the mile. The hills are represented by lines like the English maps; the forests and uncultivated ground are distinguished, and the boun-

daries showing a broad chain of black squares: the trees on the hedge-rows are shown, and every detail the scale admits of.

The meridians and parallels are given.

The diagram of the principle triangulation shows one side to be 95,185·4 Dresden feet; the average lengths of the sides appears to be about 55,000 feet. Surveyed between 1781 and 1804.

America (United States of).—Map of the United States by C. Smith, 1851: compiled from the surveys in the United States' Land Office, on a scale of 25 miles to an inch, and engraved on steel. This is a clear, well-executed map.

Map of the States by Disturnell, on the scale of 50 miles to an inch. This map is coloured and well executed, but shows only the principal divisions of the country.

Map of the State of New York, by Ensign Thayer. This map is coloured and well executed.

Map of the World; illustrated and embellished by Colton. It is 6 feet by 4 feet, and is a good map, but disfigured, as all the American maps are, with large borders.

Portugal.—1. Map of the wine district of the Alt Douro; and, 2, of the Portuguese Douro and adjacent country, to show how much of the river may be made navigable: by J. Forrester.

Switzerland.—A manuscript outline map of Mount Sentis, with contours and altitudes as an index to a model of the mountains and adjacent valleys. The scale of the map is $\frac{1}{25000}$ or 2·53 inches to a mile, that of the model is $\frac{1}{6000}$ or $10\frac{1}{2}$ inches to a mile:* by C. A. Schöll.

42. Coloured map, in relief, of Switzerland, distinguishing the cantons, lakes, rivers, roads, &c. The population, arms, &c., of the different Cantons, is stated on the margin.

This is a very pretty map, but does not aim at great accuracy.

* The assistant of M. Buchwalder, the engineer employed on the Trigonometrical Survey of Switzerland, was killed by lightning on the summit of this mountain on the 4th July, 1832.

TURKEY.—Three hydrographic charts, with soundings for the use of the navy; one is of the Archipelago, one of the Black Sea, and one of the Sea of Marmora and the Bosphorus. These charts are roughly executed; but on the same system as our own.

There are several *Moldavian* maps in the Turkish collection; one of Transylvania, Moldavia, and Wallachia, in the Moldavian language, and executed at Jassy, is clear and pretty well executed.

CHINA.—Small map of the province of Canton, in which the different towns and rivers are shown: it is exceedingly roughly executed, but the meridians are drawn so as to represent the difference between them in the different latitudes.

City of Canton—Plan of—on the same sheets as the above: the plan shows all the principal streets and buildings, the walls of the city, and the forts, in elevation, as they were in the maps of this country about 200 years ago. See, as example, the plan A.D. 1600, of Derry, in the Ordnance Memoir.

Trigonometrical Operations in France and England.—The trigonometrical surveys of France and England were commenced in 1784, for the purpose of determining the difference of longitude between the observatories of Paris and Greenwich, and for ascertaining the true figure of the earth, by measuring as many degrees of meridians as could be comprised in the triangulation of the two countries, and for obtaining an accurate triangulation as a groundwork for the National Topographical and Hydrographical Surveys.

To carry out these views, base lines were measured with great care in the two countries, and a triangulation founded on them has been carried over each, and across the Straits of Dover, connecting the one with the other. That the measurements made in the two countries should be strictly comparable, it was necessary that the relative lengths of the standards of measure used in the two

countries should be accurately ascertained, and this appears to have been effected by sending a duplicate of the Royal Society's standard scale to the Royal Academy of Sciences at Paris.

General Roy says the brass standard scale of the Royal Society, which is 42 inches long, and "contains on it the length of the standard yard from the Tower, that from the Exchequer, and also the French half-toise, together with the duplicate of the said scale, sent to Paris for the use of the Royal Academy of Sciences, were both made by Mr. Jonathan Sisson, under the immediate direction of Mr. Graham."—*Trig. Survey*, vol. i., p. 16.

In November, 1791, Mr. Ramsden compared his brass standard scale with that belonging to the Royal Society, and they were found to be "precisely" of the same length.

With this scale, Mr. Ramsden laid off 20 feet on his cast-iron triangular bar, which was the standard used in the measurement of all the bases in England; for although the base at Hounslow Heath was at first attempted to be measured with deal rods, and was very accurately measured with tubular glass rods, it was afterwards re-measured with the 100-feet steel chains used in the measurement of all the other bases, and Ramsden's 20-feet standard was referred to as the standard of measure for them all.

In commencing the survey of Ireland, General Colby had two wrought-iron standard bars, 10 feet long, made; these have been very accurately compared with Ramsden's 20-feet standard, and with each other, they are marked 0_1 and 0_2 : 0_1 is a little longer than 0_2; the ratio being as 10 to 9·9999972, and proportionally a little shorter than Ramsden's 20-feet bar, the ratio being as 10 to 10·0003828.

Bird's standard yard, 1760, generally known as the Parliamentary standard, was destroyed at the fire which consumed the two Houses of Parliament; but besides Ramsden's 20-feet standard—which, from the known skill and ability of the maker, and the great interest he took in

obtaining the most accurate standard of measure for the bases, may be safely relied on, as accurately representing six times the length of the 40 inches on the Royal Society's standard—we have also General Roy's own standard brass scale, "which was originally the property of Mr. Graham, and has the name of Jonathan Sisson engraved on it, but is known to have been divided by the late Mr. Bird, who then worked with Sisson" (*Trig. Survey*, vol. i., p. 16), and might therefore be expected to agree with the Royal Society's standard, as on comparing 3 feet taken from one with 3 feet on the other, it was found by Mr. Ramsden to be "exactly." This scale was therefore also compared with the Ordnance standard 0_1, and found also to be a little longer, proportionally, the ratio being as 10 to 10·0000104; so it may safely be inferred that the standards of measure have been very accurately preserved, and that the measured bases of France and England are strictly comparable.

In France, the base lines were measured with platinum rods, 2 toises (13·12 English feet) long; a brass rod was attached to the platinum rod at one end, and as the rate of expansion of the two rods was known, the expansion of the platinum rod was inferred from the difference between them.

With these rods, base lines were measured at Dunkirk, Melun, Brest, Bayonne, Marseilles, and Perpignan; that at Melun was 6075·9 toises, or 7·3 English miles long, that at Perpignan was 6006·28 toises, or 7·2 miles long, and calculated through the triangulation connecting it with the base at Melun was found to differ only 11 inches; and as the bases are upwards of 400 miles apart, it is a proof of the accuracy with which the operations have been conducted.

In connecting the triangulation of France with that of England, the distance from Dover to Calais, as computed by the French, was 137,442 feet, and by the English 137,449 feet, from the base at Hounslow, which shows a difference of 7 feet in 25 miles.

The following bases have been measured in England :—

	Hounslow Heath	1784 and 1791
	Romney Marsh	1787
	Salisbury Plain	1794 and 1849
	King's Sedgmoor	1798
	Misterton Carr	1801
	Rhuddlan Marsh	1806
In Ireland,	Lough Foyle	1827-8

The Hounslow Heath base was first measured with glass-tubular rods, 20 feet long, and was afterwards re-measured with the 100-feet steel chains: the length is 27404·31 feet, and the difference between the measurements was only 2¾ inches.

The Salisbury Plain base was measured with the steel chains and found to be 36576·1 feet, or 6·92 miles, and when re-measured with General Colby's compensation bars, was found to be nearly of the same length.

The accuracy with which the observations of the angles have been taken, is proved by a comparison between the measured length of the base on Salisbury Plain with the computed length from the base at Hounslow, the difference being only one inch.

The measured length of the Romney Marsh base was 28535·66 feet, and the calculated distance from Hounslow was 28 inches short of the measurement; but General Mudge says there are reasons for supposing it was not measured so accurately as the base on Hounslow Heath.

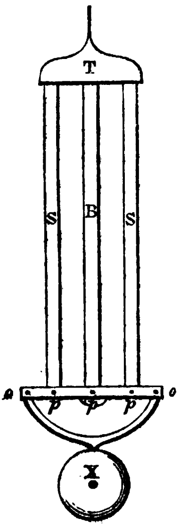
The base at King's Sedgmoor, in Somersetshire, measured 27,680 feet, and computed from Hounslow, differed one foot nearly.

The base at Misterton Carr, in Lincolnshire, measured 26342·7 feet, and computed from Hounslow, was one foot longer.

The base at Rhuddlan Marsh, near St. Asaph's, measured 24514·26 feet, and the computed length from Hounslow Heath differed only one foot.

These six bases were measured with the steel chains

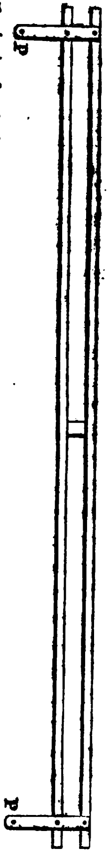
and corrected for the expansion or contraction of the chains to the temperature of 62°, and reduced to the level of the sea; but General Colby was not satisfied that the corrections for the changes of temperature could be relied on; moreover he considered that the method of bringing the ends of the rods or chains together was liable to introduce errors by disturbing their positions: for these reasons when that officer was ordered to undertake the survey of Ireland, he devised a new measuring apparatus, viz., the compensation bars now in the Exhibition, which are so arranged that the unequal expansion of the two bars of brass and iron of which they are made, compensate each other between the points used in the measurements, so that they remain equidistant under all changes of temperature. The principle of compensation has long been known and employed in the construction of the pendulums of clocks; and there is one in the French Department of the Exhibition on precisely the same arrangement as that in the compensation bars of General Colby.



The centre bar B is made of brass, and the two outer ones S of steel; these are united in T, and connected together at their extremities by two tongues moving on pivots *p*, *p*, *p*, and so adjusted that the pivots at *o*, *o*, which support the weight X, always remain at the same distance from the point of suspension of the pendulum.

The compensation bars consist of two bars of brass and iron, each 10 feet 1·5 inches long, separated from each other about an inch, and firmly riveted together at their centres. Across each end of the bars there are two flat steel tongues, projecting 3·25 inches, moving freely

on pivots in the bars, and so adjusted that the distance from the point P on the tongues to the centres of the pivots shall be in the ratio of the expansion of the bars, which is nearly as 5 to 3. By this arrangement the bars may contract or expand; but the distance between the two dots on the tongues P, P, remains invariably at the same distance of 10 feet.



To avoid the liability to errors from disturbance in bringing the ends of the bars together, General Colby invented the compensation microscopes, which are six inches apart, with a telescopic microscope in the centre. By means of these microscopes the bars are brought exactly at the distance of six inches from each other, and the whole line is measured without the actual contact of the bars or microscopes; and the base may be said to be an aerial line passing through the dots on the tongues. By means of the central microscope, the measured distances were transferred to fixed points on the ground, and so accurately has this been done, that in the re-measurement of several parts of the base line at Lough Foyle, they seldom discovered a greater error than a fractional part of a very minute dot (see account of the measurement of this base by Captain Yolland, R.E.).

The measurement of that base was further verified by computing one portion of it through triangles raised on either side of another portion of it; the difference between the measured and computed distances seldom differed more than one-tenth of an inch, and the computed distances agreed together with equal accuracy; thus satisfactorily proving the perfection of the instruments em-

ployed, and the accuracy with which both the angles and the measurements had been taken.

The instrument for taking angles principally employed by the French is the repeating circle, examples of which are in the Exhibition. By this instrument the angle between any two objects is taken with great accuracy; but the angles are not reduced by the instrument to horizontal angles as they are by the theodolite, which is preferred by the English. The theodolites employed on the principal triangulations of England and Ireland were made by Ramsden, are three feet in diameter, and are probably the most accurate instruments that were ever made.

The length of some of the sides of the great triangles is upwards of 100 miles, and many means were employed to render the stations visible from each other at such great distances. The oxyhydrogen, or Drummond's light, was employed in some instances; but a heliostat for reflecting the sun's rays in the direction of the distant observer was more generally and successfully employed. Lieut.-Colonel Porltock, R.E., who observed the station on Precelly, a mountain in South Wales, from the station on Kippure, a mountain about 10 miles south-west of Dublin, the distance between the stations being 108 miles, says, "For five weeks I watched in vain, when to my joy the heliostat blazed out in the early beam of the rising sun, and continued visible as a bright star the whole day."

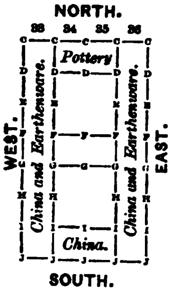
With the view of determining the exact size and figure of the earth, arcs of meridians have been measured in different parts of the world, in England, in France, in Peru, in Lapland, at the Cape of Good Hope, and in India. The point selected by General Mudge as the southern extremity of the arc of the meridian to be measured in England, is Dunnose, in the Isle of Wight: this was connected by triangulation with points at Aubury Hill, Clifton, and Burleigh Moor, in Yorkshire; and he estimated that in latitude 52° 2′ 19″, the length of a degree was 60·820

fathoms; and in 52° 34′ 45″, that the length of a degree was 60·823 fathoms; and that the polar diameter of the earth was 7,882 miles; and the equatorial diameter 7,935 miles.

The triangulation has since been extended through Scotland to the Shetland Islands, but the results obtained have not yet been made public.

Class XXV.—China, Porcelain, Earthenware, &c.

Situation of Class.—*In the North Transept, Western Galleries, extending Eastward from* J. 33 *to* 36, *and Northward to* C., *occupypying two Galleries.*



Positions of Groups.—The front portions of the Galleries are devoted to Porcelain Manufactures, the Northern parts being reserved for Earthenware and the ordinary manufactures of the potter.

The introduction to this class properly begins in Class I., since within that section are gathered together the raw materials, of which the beautiful finished manufactures exhibited in the Gallery are formed. There are the clays of which the "bodies" of the wares are formed, and the decomposed granite which is now so extensively used to glaze the finest kinds of pottery (see page 41). Amongst the more remarkable productions of the potter must be named those very popular statuettes which are formed in the material known as parian, statuary porcelain, &c., to which we would first direct attention.

Statuary Porcelain.—(Exhibitors 1, 2, 6, 10, 11, 14, 26, 47, 60.)—At all times man appears to have adopted clay as a material out of which to fashion likenesses of his fellows and of the animals inhabiting the earth. The earliest inhabitants of the Old and the New World have left us examples of rude forms thus moulded.

In all countries, and through all time, the potter has found a profitable source of his industry has been moulding likenesses of humanity. However, though this feeling to possess, in a cheap material, images, whether for

ornament or superstition, has always prevailed, the production of a material which should realize the desires of the artist, in which we should be enabled to reproduce the choicest works of the sculptor, has been reserved for our own time.

The first idea of imitating marble in ceramic manufacture originated with Mr. Thomas Battam, the artist directing the extensive porcelain manufactory of Mr. Alderman Copeland, at Stoke-upon-Trent, in the commencement of 1842. After a series of experiments he succeeded in producing a very perfect imitation of marble, both in surface and tint. One of the earliest specimens was submitted to His Grace the Duke of Sutherland, who expressed his unqualified admiration of the material, and his high appreciation of the purposes to which it was being applied, and became its first patron by purchasing the example submitted. This was on the 3rd of August, 1842, a date which marks a memorable event, as the commencement of a trade now not only of large commercial advantage to the potteries generally, but fortunately of a class that has most materially advanced the artistic state of English ceramic manufacture. Some groups of Graces and Satyrs for Kaneophoroi, and also large Caryatides for fire-places, and a variety of garden vases and brackets, were also executed. In 1843, amongst other works, the equestrian statuette of Emanuel Philibert, by the Baron Marochetti, was produced; also the Warwick Vase of a large size; and other large vases for conservatory purposes. It was also introduced, in conjunction with coloured and gilt decoration, on ornamental pillars and vases; a copy (reduced size) of the beautiful statuette of 'the Goatherd,' by the late S. P. Wyatt, R.A., from the marble in the possession of the Duke of Sutherland, was also executed.

Its operations were comparatively confined until 1844, when it was seen by Mr. Gibson, R.A., when that eminent sculptor at once declared it to be "the best material next

to marble," and also expressed his desire to see one of his own works produced on it.

Mr. S. C. Hall's opinion was equally favourable with that of Mr. Gibson; and that gentleman proffered to submit a specimen to the council of the Art Union of London, and to urge their adoption of the material by commissioning a number of copies of some work of acknowledged excellence, to be awarded as prizes to their subscribers. This was done; and Mr. Gibson having expressed a great interest in its progress, generously gave permission for a copy to be made of his marble statue of Narcissus in the Collection of the Royal Academy.

The production of the statuettes, vases, &c., exhibited in this material involves the following manipulatory details:—The material is used in a liquid state, technically termed "slip," about the consistency of thick cream. It is poured into the moulds forming the figure or group, which being made of plaster, rapidly absorbs a portion of the moisture, and the coating immediately next the mould soon becomes of a sufficient thickness for the cast, when the superfluous "slip" is poured back. The cast remains in the moulds for some time at a high temperature, by which it is (through the evaporation that has taken place) reduced to a state of clay, and sufficiently firm to bear its own weight when relieved from the moulds, which are then opened, and the different portions of the subject taken out. Each figure requires many moulds; the head, arms and hands, legs, body, parts of the drapery, when introduced, and the other details of the subject, are generally moulded separately. In one group, representing 'The Return from the Vintage,' consisting of seven figures, there are upwards of fifty moulds, and each of these in several divisions; these parts being removed have then to be repaired, the seams caused by the junctions of the mould cleared off, and the whole put together. This is a process requiring, when well executed, the greatest nicety and judgment, the fragile nature of the material in its

present state rendering considerable practical knowledge necessary to form a perfect union of the different members, and also that they are so disposed as to be in strict accordance with the original model; for, though made from the same moulds, it by no means follows that all the casts will possess equal merit, so much depending upon the taste and skill of the finisher,—the figure-maker. Peculiar care is required in putting together nude figures, in which the junction of the parts, generally presenting a level circular surface, requires the decision of an educated eye to fix with accuracy. Surfaces that possess a marked and broken outline, which will only fit together at one particular point, are, of course, exempt from this difficulty. Want of judgment in this respect will often cause such a deviation of outline, as seriously to injure the beauty of the work. The parts are attached together by a "slip," similar to that used for casting, the surfaces to be joined together being either dipped into it, or the "slip" is applied with a pencil; and according to the discretion with which this is executed, and the neatness with which the sections of the moulds are made to fit, will be the greater or less prominence of the seams which so often disfigure pottery castings. It is possible, with care, that these seams shall be so trifling as to be scarcely perceptible, even upon a close examination; and it is only the want of proper precaution, that the contrary is too often the rule instead of the exception. The "slip" in this case is merely required to soften the surface of the clay of the members which have to be united, just sufficiently to cause adhesion. All that is used beyond that requirement is not only superfluous, but actually detrimental; moistening the part to which it is applied so much that the edges become pliant, and yielding to the pressure while being attached, distort the outline, and by causing unequal shrinking in the process of firing, the junctures become evident and unsightly. This fact cannot be too forcibly impressed upon those engaged in this branch of the art,

as it is of the greatest importance to their interests, for exactly in proportion to the beauty and perfection to which these objects are produced, will this novel and valuable introduction merit and obtain success.

The figure or group being thus put together remains two or three days, when, being sufficiently dry, it is supported by "props" made of the same material, placed in such positions as to bear a portion of the weight, and prevent any undue pressure that might cause the figure to sink or yield in the "firing." Each end of the "prop" is embedded in a coating of ground flint, to prevent adhesion, and is thus easily removed. It is then placed in the oven, and submitted to a heat of about 60° of Wedgwood's pyrometer. This operation, which is gradually effected, occupies from 60 to 70 hours. The fires are then withdrawn and the oven allowed to cool; and when sufficiently so, the figures are drawn out, and the seams rubbed down; they are again placed in "saggers" and embedded in sand, and then re-fired at a still higher temperature than they were previously submitted to. The bedding of sand is preferred in this part of the process to "props," as it more equally and effectually supports the figure. It could not be used in the first instance when the figure is in the clay, as by resisting the contraction, it would cause it to be shattered to pieces; it is even sometimes necessary to *fire* casts three times, a peculiar degree of heat being required to produce the extreme beauty of surface which the finest specimens present. The total contraction of the figures from the mould to the finished state is one-fourth; the contraction of the "slip," with which the mould is first charged, to the state in which it leaves the mould, is one-sixteenth; again, it contracts another sixteenth in the process of drying for the oven, and one-eighth in the process of vitrification—so that a model 2 feet high will produce a fired cast of 18 inches only. Mr. Minton states the contraction of their improved composition as being but little more than one-fifth.

By multiplying the beautiful, and thus diffusing a true taste for art, considerable improvement must be the result of the introduction of this material. The examples spread around this Gallery are, many of them, singularly beautiful, considering the difficulties which has to be overcome in producing one of the figures.

The Victoria Dessert Service will naturally attract attention from the novel introduction of parian with porcelain. The service is a full one, consisting of—2 wine coolers, 2 *assiettes montées*, 2 oval baskets, 2 round flower baskets, 4 triangular ditto, 4 jelly stands, 4 saltcellars and stands, 20 compotiers, 4 cream tureens, and 72 dessert plates, perforated, the borders in turquoise and gold, the centres and compartments variously painted with birds, flowers, and fruit, Cupids, &c. The service is in white, turquoise and gold, the plates and smaller portions being exclusively porcelain, the large centre pieces, such as *assiettes montées*, flower baskets, and cream bowls, porcelain and parian combined. The-wine cooler, which stands in the centre, is exclusively parian, and is of a high order of art. Round the outside it has, in bas-relief, a bear hunt represented, and hunters with their dogs form a series of statuette groups round the pedestal. A thread of gold runs in and out through the design, and the whole has a most exquisite effect, the dead richness of the parian contrasting admirably with the bright glaze of the porcelain pieces. On the top an infant Bacchus is busy pressing the grapes, for the juice of which a receptacle is provided underneath. The *assiettes montées* are most graceful combinations of the two materials, and the top of the jelly-stands are formed by the group of two Cupids—one struggling to get the sweet things beneath, the other holding him back with the energy of an outrageously good child. The minor articles are all enriched with parian statuary, and the whole has a richness of effect which it would be in vain to look for in services composed exclusively of one material. It should be remarked that this service was not made originally to

royal order, but merely as a specimen for the Exhibition. Her Majesty, in passing through the Gallery, was struck with its beauty, and purchased it for a thousand guineas for the purpose of presenting it to the Emperor of Austria. We believe the expense of designing, modelling, and decorating it far exceeded that of any other service ever before manufactured in this country; and it must be gratifying to the enterprising firm that produced it, that it has been deemed worthy of selection by royalty, with the view of proving to the people of other lands what can be effected by English industry and talent in a department of art to which only the attention of a few brief years has been devoted. The whole of this laboriously artistic production was completed within the short period of twelve months.

The parian chimney-piece is a very striking production. It will be viewed with pleasure as a work suggestive of many previously unthought-of objects of utility and ornament to which the material may be applied.

Porcelain.—With but one or two exceptions, each exhibitor, from 1 to 60, has some examples of this manufacture. True porcelain is of comparatively recent introduction in this country; the discovery of the value of the Cornish china-clay at the latter end of the last century by Mr. Cookworthy, of Plymouth, being the commencement of this manufacture. It is composed of an infusible china-clay and a fusible flux. The body formed by the kaolin, or china-clay, alone would be found to be an exceedingly porous one; but the flux, which is composed of felspar, quartz, and gypsum, is melted in the heat of the porcelain furnace, and completely filling all the pores of the clay, binds the whole into a firm mass.

Microscopic examination shows that porcelain consists of small opaque particles, arranging themselves in linear directions, while the transparent flux has interfused itself through the whole mass. The chemical composition of it is—

Silica . . .	58 grains.	
Alumina . .	35	"
Lime . . .	5	"
Potash . . .	2	"

The glaze for English porcelain is formed from the china-stone of Cornwall, which is a peculiar variety of decomposed granite, the mean composition of it being—

Silica . . .	73 grains.	
Alumina . .	18	"
Potash . . .	9	"

The chemical utensils exhibited by Messrs. Minton is one of the most recent successful additions to British manufacture. We have hitherto been entirely dependent upon the manufactories on the Continent, particularly of Berlin, for this variety of hard porcelain. The exhibitors (46) have also similar examples, called by them "semi, or chemical porcelain." Since it is impossible to describe in detail the varieties of ornament introduced by our potters either in the way of painting or gilding, we can only select the greatest novelties.

There is a pair of vases (1), the one turquoise ground, the other Bleu de Roi, which command much attention from their colossal size, their beauty of form, and the chaste manner in which they are ornamented in the jewelled style of old Sèvres. They have or-molu and oxidised silver handles, manufactured by Messrs. Elkington, of Birmingham. They are amongst the largest that have ever been made in porcelain in this country, and prove that the potter's art is not only rapidly advancing in regard to beauty of form and ornamentation, but also in the command he possesses over the fragile material he has to operate upon.

Many other vases by the same exhibitor, as the rope festoon vase, in mazarine and Sèvres green, the egg-form, and the perforated vase, are fine examples sf this class of manufacture.

The "Dove tazza," (2) in which the birds are adaptations

of the celebrated doves of the Capitol, is a very splendid work: the doves and the embossed ornaments executed in solid gold chased. The wreaths of flowers on panels bounded by turquoise grounds are very effectively introduced. The large Etruscan vase, ornamented on blue and gold foliated scrolls, supporting wreaths of flowers; the jewel vases—the pair of vases, "Queen colour" ground—landscapes on panels of raised gold, chased and enriched with pearls—and the *fac-simile* of an ancient Greek votive vase used at the Olympic games, from the original in the possession of Sir Woodbine Parish—are very excellent specimens of the art of the potter.

In the productions exhibited by Wedgwood and Sons (6), we find much that is interesting, as representing the improvements made by the celebrated Wedgwood, who, by the efforts of his energetic mind, within a very short period, advanced the art of the potter in this country from a state of comparative rudeness to one involving the applications of high art.

The works from Coalbrooke-dale (47) also present considerable novelty; those from Worcester (44), particularly the pierced or honey-comb china, illustrate the peculiar manufacture of that locality where the porcelain manufacture was established in 1751. The Rockingham china (43), was so named in compliment to the celebrated Marquis of Rockingham, to whose patronage was due the introduction of the very fine porcelain known by his name. This, like most of the English porcelains, consists of a clay body, through and over which the glaze is diffused.

In 1751, Dr. Wale established a manufactory in that town under the name of the "Worcester Porcelain Company."

The original Worcester Company principally confined themselves to making blue and white ware, in imitation of that of Nankin, and in producing copies of the Japanese pottery.

Cookworthy, of Plymouth, the discoverer of the china-

clay, appears to have carried on the business of a potter, in Worcester, until 1783.

In colour, the greatest novelty appears to be the revival of the Rose Dubarry (23), which was manufactured for the exhibitor by the Coalbrook-dale Company. Madame Dubarry having some vases executed at the Sèvres works, the rose colour was adopted, as being the lady's favourite, in compliment to her. Colours of this character are usually produced by combinations of gold with salts of ammonia, to which sometimes tin and the oxide of manganese is added.

The egg-shell china exhibited by Nos. 12 and 47, will be examined with curiosity, as a very close approach to those remarkable specimens of Oriental manufacture which are so much valued by collectors.

Earthenware. (Exhibitors 1, 2, 4, 6, 8, 9, 13, 20, 25, 28, 33, 36, 37, 41.)—Common earthenware is distinguished by its complete opacity; and, from its containing undecomposed carbonate of lime in the burnt mass, it is often, in its unglazed state, found to effervesce with acids. We confine the term earthenware, in this instance, to the white ware, employed as common dinner sets, &c., reserving our notice of the Majolica ware, &c., until we notice the tessera and terra cotta, found also in the section devoted to mineral manufacture. The following is given as the practical formula for ordinary earthenware:—

6 barrowsful of brick clay;
4 barrowsful of blue clay;
2 barrowsful of cracking clay;
8 barrowsful of the above in "slip," *i.e.* ground into mud in water;
4 barrowsful of Cornwall clay;
7 barrowsful of flint;
1½ barrowsful of Cornish stone.

The earthenware is usually glazed with some such composition as the following:—

Decomposed granite . . .	25 parts,
Carbonate of lime . . .	3 „

Flint	. . . .	10 parts,
Litharge	. . . .	46 „
Borax	. . . .	16 „

The ingredients are all ground together in glaze mills, and the glaze is used sometimes in a liquid state, and sometimes in powder. A number of these glazes will be found at 27, many of which are said to be new.

Printing on Earthenware. (Exhibitors 19, 49, 51.)—To Dr. Wade appears to be due the idea of printing upon earthenware, the transferring of printed patterns to biscuit ware as now usually adopted. From a mug executed by Dr. Wade, in the Museum of Practical Geology, decorated with a Portrait of Frederick the Great, the date of this process appears to be 1757.

It is a process of much interest. A printing-ink of the desired colour — cobalt blue, manganese black, or chromium green—is mixed with linseed-oil varnish, and the copper-plate impression is printed with this ink upon thin paper in the usual manner. This print is carefully placed on the porous *biscuit*, with the printed surface towards the earthenware, and the article to which it is applied is dipped into water. By this the paper is softened, and can be brushed away, while the coloured varnish ink, which is not affected by water remains as a picture upon the ware. The varnish of the ink is destroyed by heat: this is called "hardening;" it is then glazed, and the designs finally burnt in.

Stone-china. (Exhibitors 3, 9, 20, 36.)—Stone-china differs from the "tender porcelain," as the English manufacture is usually termed, in being a fused body; the alkali of the clays employed being, by the heat of the furnace, made to combine with the silica and alumina.

Terra-cotta, Majolica-ware, Encaustic Tiles, Tesseræ, and other examples of clay manufacture, must be described in connection with Class XXVII., "Mineral Manufactures," these articles being unfortunately divided between these two classes.

Stone-ware. (Class XXV., Exhibitors 3, 26, 35; Class XXVII., 7, 22, 23, 107, 110, 115, 123, 125, 127, 131.)—A variety of articles in stone-ware in the latter class should also be inspected.

Stone-ware is a dense and highly-vitrified material, impervious to the action of acids, and of peculiar strength. Until within the last 15 years its application was very limited, being used chiefly for common spirit-bottles, oil-jars, ink-bottles, &c.; but, when the duty was taken off, and the manufacturers were relieved from the restrictions and surveillance under which they laboured, the improvements in the manufacture received an impulse which has greatly enlarged the sphere of their operations.

The process of manufacture is as follows:—The clay used is found near the coast in Devonshire and Dorsetshire: it is dug in square lumps of about 40 lbs. each, and transported to London in the coasting vessels. When received by the potter they are, after being perfectly dried, ground to a powder, mixed with water, and, after being allowed sufficient time to become of uniform consistency, the mass is passed through pug-mills, and is then fit for the operation of the workmen.

For making large vessels it is necessary to introduce into the composition portions of the burnt material, finely ground; also some of the white sand found in the neighbourhood of Woolwich and Reigate.

Almost all round vessels are formed entirely by the hands of the potter on wheels, turning at a rate decreasing in rapidity in proportion to the size of the article to be made. Vessels of other shapes are cast in plaster-of-Paris moulds. The composition is laid in them in a soft and plastic state: the porous plaster gradually absorbs the moisture from the clay, till in a short time it is sufficiently firm to be removed from the mould, which is again filled. Some thousand articles are frequently made from one mould before it is destroyed.

When thoroughly dry the ware is placed in ovens or

kilns constructed for the purpose, and exposed to a gradually-increasing heat, so intense as to become, before finishing, quite white; salt is then thrown in, and, being decomposed, the fumes act chemically on the surface of the ware, and fuse the particles together, giving the glaze so well known. Stone-ware differs from all other kinds of glazed earthenware in this important respect, that the glazing is the actual material itself fused together; in other kinds of ware it is a composition in which the vessel is dipped while in what the potters call *biscuit*, or half-burnt state. The heat to which stone-ware is exposed is so intense, that if a piece of iron or steel should by any accident be left in the kiln amongst the ware, it is entirely destroyed, being oxidized, and the oxide to a great extent volatilized.

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